Can ideas be dangerous?

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ABSTRACT

Science thrives on ideas, and within its domain no idea is inherently dangerous. However, interpretations of science, and applications of misinterpretations in policies have potential to be dangerous to scientists, science itself, the broader society and the environment. I discuss a number of examples of dangers from outside science where conclusions reached by practitioners in other in other disciplines may lead to confusion as to what the science says. In particular I present an extensive discussion of Gammage's *Biggest Estate*, suggesting that the evidence for universal application of one Law applied to land management over the entire continent for many thousands of years is not strong, and that other interpretations should be tested. Assumptions that the British colonists were unfamiliar with fire in the environment are questioned.

Key words: Lysenko, economic and other models, environmental history, landscape art, Aboriginal fire, fire management, sense of place.

DOI: https://doi.org/10.7882/AZ.2017.008

Introduction

The question in my title can only be answered by considering what is meant by dangerous, who (or what) might be in danger and the context in which the question is raised.

If we restrict the context to being entirely within the realm of science then I would argue that no idea is dangerous – an idea may be silly, ill considered, wrong or inappropriate but not intrinsically dangerous. In the practice of science, methods have been developed for the testing of ideas and the sorting out of the wheat from the chaff. However, science does not exist in a vacuum, and even those in ivory towers cannot (nor should they) totally remove themselves from interactions with broader society.

In recent years "Dangerous Ideas" have been the subject of festivals; events designed to provoke and stimulate audiences by presenting ideas and hypotheses. Pinker, in the introduction to Brockman (2006), says of dangerous ideas that they are statements of fact or policy that are defended with evidence and argument by serious scientists and thinkers but which are felt to challenge the collective decency of an age. A decade on, in the age of alternative truths where evidence becomes irrelevant, dangerous ideas are emerging outside civilised debate.

The application and implementation of particular scientific ideas may well involve intrinsic dangers, and the misinterpretation of ideas can lead to inappropriate actions and policies.

In some cases the understanding and expectations of scientists by politicians and the broader public may be dangerous for the well-being of society, science and individual scientists.

Philosophers of science debate the nature of science and approaches to the conduct of science, but I see merit in the writings of Kuhn (1962) who argued that, in any particular discipline, progress was achieved, not at a constant, steady rate, but rather through brief periods of scientific revolution (which have come to be called paradigm shifts) separated by long periods of incremental change. The vast majority of scientists, through their publications, contribute to the phase of incremental change – revolutions are rare. The ideas generated during a revolution may be challenging, even disconcerting, but nevertheless should be welcomed by scientists.

The rarity of revolutions should not be interpreted as meaning the majority of scientists, for the majority of their careers, are time (and other) resource wasters. Without the steady incremental accumulation of data and testing of hypotheses the springboard for the next revolution would be absent. When revolutions do occur we need (to use terms currently very much in fashion) to be sufficiently agile and nimble to both seize the moment to advance our disciplines, and equally to explain to a broader public why the outcome of revolution may be important and valuable to society.

Scientific revolutions rarely arise out of the blue. The ideas behind them may have been in circulation for years,

but it requires a particular form of genius to recognise the importance of previous ideas and to synthesise these with new evidence into the revolutionary advance. Thus the idea that continents are moving had been advanced by a number of scientists (for example Wegener 1915) for decades before plate tectonics came to be the new paradigm. The early proponents of moving continents were prophets crying out in the wilderness, the pieces of evidence which were advanced to support the theory were not, of themselves, sufficient to persuade the majority of geologists of the credibility of the concept. Nevertheless evidence in support of continental drift continued to accumulate, particularly in the 1950s and 1960s with new findings in geophysics. The various lines of evidence were discussed at a symposium of the Royal Society of London (Blackett, Bullard & Runcorn 1965), which can be identified as the moment when the theory of continental drift (as a consequence of plate tectonics) became the new prevailing paradigm.

Plate tectonics theory was not only a revolution in geology – it wrought a change in our understanding of biogeography and evolution – permitting, for example, new understanding of the origin of the biota of Australia and recognition of the global significance of Australia's rainforests (Adam 1992). The acceptance of plate tectonics led to promotion of vicariance as the explanation for the distribution patterns shown by many higher taxa in what were recognised as components of the former southern hemisphere supercontinent Gondwana. Interestingly, although this interpretation is supported for many taxa by more recent molecular data it is now clear that some distribution patterns postdate the split up of Gondwana and, for some taxa, there has been more recent long-distance transoceanic dispersal. This is seen, for example, in the Proteaceae (Weston 2014). This sets major challenges to our understanding not only of the mechanisms of dispersal but also of establishment – how, after long-distance dispersal, do species cross the inhospitable beach and strandline to begin establishment on land?

These findings do not disturb plate tectonic theory, but do suggest that as part of the incremental advance of science there are many points of detail still to be explored.

The continental drift/plate tectonic revolution was undoubtedly a challenge to those who had previously accepted, without question, the previous paradigms, which, while allowing for changes in the distribution of land and sea and for orogenic episodes, nevertheless regarded continents as essentially fixed. However, plate tectonic theory was not regarded as dangerous by scientists; the rapid accumulation of supporting evidence, and the explanatory power the paradigm provided was such that its acceptance was rapid. While the new ideas attracted considerable media coverage they were not regarded as dangerous, or even challenging, by the broader community either (except, perhaps, by the few adherents to a flat earth theory).

Plate tectonics is typical of paradigm shifts in science in that it rapidly became accepted and the discipline continued to advance by developing and testing ideas which arose from the new paradigm. Paradigms by their very nature are rarely amenable to direct testing and falsification in their entirety, rather it is the individual pieces of the jigsaw which can be tested. Plate tectonics is similar to paradigm shifts in most disciplines in that once the new paradigm is recognized it appears as a revelation of the obvious and the major interest is not in disputing its validity but in taking advantage of the new understanding.

Does this mean that there are no dangerous ideas, merely constructive ones and that the underlying premise of the forum was flawed? I would suggest that there are indeed dangerous ideas which fall into various non-exclusive categories:

- bad science, the application of which is dangerous to the community at large; (Here, I am using 'bad' because of the potential consequences, and thus drawing attention to a much smaller category that 'flawed' science.)
- ideas which are perceived as dangerous to the world view of the beholder;
- ideas which arise from outside science (or from other disciplines within science) which are promulgated as unquestionably the right answer to a problem;
- perceptions or misperceptions of the nature of science, which if applied, have a real or potential capacity to damage both science and society;

policies and practices which were introduced without anybody understanding the complexity of the issues to which they gave rise.

I would also suggest that the hubris of scientists who fail to acknowledge the complexity of the social, economic and political context to which science is applied can be 'bad' both for the standing of science and for practical outcomes. Debates about environmental issues are replete with examples of argument where it is claimed that there is but a single answer to a problem, and that is the one advocated by particular scientists.

Science which is 'bad' for the community, and for scientists

An outstanding example in this category was the work and influence of Trofim Denisovich Lysenko. Lysenko was an agronomist who came to wield enormous power and influence in the Soviet Union for more than 20 years from the late 1930s. He claimed to have demonstrated that crop plants could acquire, following suitable treatment, characteristics providing for greater yields. The concepts were essentially Lamarckian, although

in the Soviet context the horticulturist Michurin was lauded as the intellectual predecessor. Under Stalin's patronage, Lysenko rose to high positions in the USSR Academy of Sciences, and controlled the direction and application of Russian research in much of the biological and agricultural sciences.

If Lysenko's research could have been substantiated he would have been responsible for a paradigm shift. Unfortunately much of his work was essentially fraudulent, although not fraud committed for personal financial gain (Lysenko was a communist); the power and prestige associated with his position in the hierarchy were clearly important to him. This had disastrous consequences for Russia and for many individual scientists. Application of the agricultural practices advocated by Lysenko failed to produce the anticipated bounty, with consequent widespread food shortages and famine. Areas of research in genetics and mineral nutrition of plants were closed down and many scientists lost their positions. In some cases, scientists were consigned to the Gulag where some, including the great plant geneticist Vavilov, died (Pringle 2008, an outline of Vavilov's work has been provided by Thompson 2010). Lysenko's rejection of Mendelian genetics extended beyond the research community to the Soviet education system so that a generation of students grew up indoctrinated against Mendel (see Ashby 1947, Huxley 1949, Goldsmith 1980). In the west, the schism between supporters and opponents of Lysenko festered for many years, and the unfortunate lesson taken from the experience by many scientists was not to become involved in public controversy.

Lysenko, and Lysenkoism, can be viewed as an aberration, a blot on the history of science. However, we should perhaps see it as a warning about how easy it might be for bad science and ideology to combine, and how far reaching the consequences of such a union might be. A number of commentators, including Australia's chief scientist, Dr Alan Finkel, have suggested that President Trump's promotion of political control of science is reminiscent of the Stalin era, and Lysenkoism (Hutchens 2017) While many of the utterances about science from the White House in early 2017 have been worrying at many levels, there is no obvious equivalent of Lysenko, with President Trump's ear (as Lysenko had Stalin's) in American science.

There have been many examples of bad science throughout history, some arising from outright fraud, conducted with the aim of personal benefit, some out of a delusion that the end justifies the means, and that the end is a clear public good. Intentional fraud can be well camouflaged and not readily detected by the peer review process. There is a continuing need for vigilance, and where fraud is detected it needs to be publicly exposed. One of the problems of the modern age, with so much material available on the Web, is that it is difficult to eradicate bad science – and the gullible and desperate will continue to find and believe in findings long discredited in the mainstream. There are few data to determine how prevalent fraud is – we like to think it is relatively rare, and that our education systems inculcate an understanding of, and respect for, an ethical professional ethos, but this may be self-delusion.

Detected cases of fraud are relatively rare and whether or not they are increasing is difficult to evaluate, but that could reflect that the perpetrators are successful in covering their tracks. The most publicised cases occur in medical research or related disciplines, where the potential for financial rewards and reaping society's acclaim are large. The rewards in zoology and ecology are less, but nevertheless they have been cases of taxonomic fraud (Luck 2014) and planting of rare species so that the planter can subsequently make unexpected finds (Sabbagh 1990). Beyond the outright fraudulent there is an extensive murky area of grades of incompetence – inappropriate study design; misidentifications and inadequate sampling; statistical errors (compounded by the uncritical use of 'blackbox' statistical packages, Goodall 2014) and incorrect interpretation of results and misinterpretation of prior literature. These sorts of bad science are what the peer review system should capture, but the mechanism is less than perfect. In some cases there are genuine grounds for conflicting views about the appropriateness of, for example, a particular statistical approach, but even straightforward errors persist in published works. There are a number of reasons for this, including: the sheer volume of submitted manuscripts and the increasing difficulty of finding reviewers willing to be referees; the extreme time pressure that many journals now impose on reviewers, so that reviews are often superficial; the tendency to ignore the clear message of reviewers following a rejection and for rejected manuscripts to be resubmitted to other journals, often with little change, until finally a manuscript is accepted (the chain may be six or seven journals long). However, I would not suggest that high-ranking international journals necessarily have more stringent reviews than some more local journals – the sort of publication which might be summarily dismissed by appointment and promotion panels. Often the reviewers for these 'local' journals have greater familiarity with the subject matter and can detect problems missed by reviewers for international journals.

Even where design and analysis problems are well-known they persist, for example, pseudo-replication and pseudo-factorialisation (Hurlbert 1984, 2013, see Goodall 2014) – these can be tricky issues for field ecology and the exploitation of natural experiments, but failure even to acknowledge that there is problem is of concern.

These sorts of bad science substantially reduce the worth of much published work and the problem is one which, for the credibility of the profession, needs much more serious attention.

Acceptance of bad science is bad for the public reputation of, and trust in, science, particularly when bad science is used as the ostensible justification of policy. In this regard the International Court of Justice's 2014 decision on the Japanese 'scientific' whaling program in the Southern Ocean was welcome. The Court found that the program was fundamentally flawed. The principal issue for the Court was whether the program was 'for the purpose of scientific research'. The Court separated this phrase into two parts for its analysis – 'scientific research' and 'for the purposes of'. The Court was reluctant to arbitrate on what constituted 'scientific research' (particularly in relation to the characterisation of the requirements for scientific research contended for by Australia). However, the Court did find that the take of minke whales was in excess of that required to address the stated aims of the scientific program, and was thus 'not for the purposes of scientific research'. This is not to argue against research on whaling, indeed part of Australia's case was that more, and more useful, data could be collected without involving the death of whales. Nor necessarily is it an argument against, at least in theory, the harvesting of whales – although the case for whaling would need to surmount both scientific issues and very widespread public opinion. The Court's decision only related to Japan's activities in the Antarctic – it has no effect on Japan's continuing whaling in the North Pacific. In practice, after a short hiatus, Japan recommenced its activities in Antarctic waters.

Dangerous ideas which threaten civilisation as we know it

Ideas are important – as was well realised by Keynes (1936): "The ideas of economists and political philosophers, both when they are right and when they are wrong, are more powerful than is commonly understood. Indeed the world is ruled by little else. Practical men, who believe themselves to be quite exempt from any intellectual influence, are usually the slaves of some defunct economist. Madmen in authority, who hear voices in the air, are distilling their frenzy from some academic scribbler of a few years back. I am sure that the power of vested interests is vastly exaggerated compared with the gradual encroachment of ideas."

Keynes was arguing against the body of political economic theory which was developed in the late 18th century and through the 19th century. In the late 20th and early 21st centuries, the economist most frequently regarded by the economic rationalists as deranged and dangerous was Keynes himself (see for example, Ebeling 2006).

Ideas which arise from academia, only to be developed, misunderstood and misapplied by madmen in authority (the modern term which summarises this process is 'spin') can come from many disciplines, but ideas about economics and their application to society are perhaps some of the most dangerous ideas in circulation. Modern political systems are wedded to particular economic theories, which are rarely tested, but which have the power to influence not only the workings of human societies but also their interactions with the environment.

Economics, like all disciplines, is not monolithic; there are different schools (Keynesianism, monetarism, economic rationalism etc.) and a variety of opinions on many issues, but the prevailing orthodoxy, at least amongst governments (of all political persuasions), business and the mainstream media is very much pro continuing growth, with GDP being the major measure of national progress. Counter views are tolerated but marginalised– for readers of the *Sydney Morning Herald* Ross Gittins has long presented views which recognise the problems caused by increasing consumption to both society and the environment. While the letters to the editor of that newspaper demonstrate that these views strike a chord with readers, they have little impact on governments or the big end of town. Environmental economics has developed as a sub-discipline and supports a number of international journals, but in many tertiary institutions it is still not regarded as a core strand in undergraduate programs. Dialogue between ecologists and environmental scientists on the one hand, and economists on the other, is still relatively limited. Despite ecology and economics having a common etymological root, members of the two disciplines frequently appear to have very different views of the world.

One of the publishing successes of 2014 was Piketty's *Capital in the twenty-first century*. This was received with both high praise and opprobrium from reviewers. Reviewers in the Right of Centre UK press were particularly savage – Sir Max Hastings in the *Daily Mail* claiming that the book is 700 pages of poppycock. The impression from some of the UK reviews is that the reviewers' principal objection is that Piketty is French – quelle horreur! Others on the Right have been kinder, even though disagreeing with the book's conclusions. Smith (2014) in *Quadrant* and Cohen (2014), in *Foreign Affairs,* both point to the importance for future researchers of the large body of data collected and analysed. This highlights that some, perhaps much, conventional economic theory has limited empirical basis. Remarkably, commentary on Picketty in the year of publication was not restricted to book reviews but included at least one book (BWBTexts 2014).

Piketty's (2014) thesis, derived from his data analysis, is that the capitalist economic system results in increasing inequality of wealth. To address this he proposes increased taxation and, in particular, a global wealth tax. Related to, but not the same as, inequality in wealth is social inequality. One of the stated goals of policies of many political parties is that they will increase social mobility, hence reducing inequality within society. Clark (2014) has recently analysed social mobility over centuries in a number of societies from both Eastern and Western cultures, including examples of those generally considered to be more equal (Sweden) and those where social

inequality is considered to be high (England), employing the novel approach of tracking cohorts of unusual surnames over time. He finds that the rates of change in social position have been, on average, slow. There are exceptions of course in the form of rags to riches changes (and the converse) which are highlighted by the media, but the occurrence of such changes hides the relative fixity of social structure over very long periods.

Advocacy of policies to increase social mobility may not be dangerous to society, but might qualify as false advertising. To those at the top of the tree, the idea that they might be knocked off their perch by social climbers from below is likely to be discomforting and probably dangerous. The power of privilege supports the privileged in the maintenance of the *status quo*.

Piketty's solution, to a problem which not all his critics see as a problem, is anathema to his opponents. Indeed, even those sympathetic to Picketty see difficulties with the practicalities and effectiveness of a global wealth tax. Smith (2014) concludes, "We can relax. Capitalism will continue to make the world more prosperous. A freer capitalism would bring more prosperity still. If along the way some do much better than others it is a small price to pay."

However, as Daly (1982), an urban geographer, discussing property speculation, concluded "capitalism is an insidious disease, – the distinction between activities which are considered useful, normal, or even honourable, and those which are in some way reprehensible is often one of degree rather than of kind." The collateral damage to the environment from some types of economic activity is still not regarded as reprehensible by governments and large sections of society (or if considered reprehensible, is nevertheless tolerated as the regrettable, but inevitable, price of 'progress') and externalities are still not adequately, if at all, taken into account in drawing up cost-benefit analyses.

A great deal of economics, and the policies that derive from it, is based on models. The criticisms by some economists of climate change science for its reliance on models (Lawson 2008; Darwall 2013) thus have an element of pots calling the kettle black. Piketty (2014) is critical of the expression 'economic science' – which he regards as 'terribly arrogant'. He suggests that "for far too long economists have sought to define themselves in terms of their supposedly scientific methods. In fact these methods rely on an immoderate use of mathematical models, which are frequently no more than an excuse for occupying the terrain and masking the vacuity of the content." - sentiments unlikely to endear him to the discipline at large!

Whether economics should be regarded as science is a much debated question. The description of economics as 'the dismal science' was first made by the Scottish essayist Thomas Carlyle in the mid-19th century. There is a widely held view that the term was coined in reference to Malthus' work (at least this is what Google will tell you), but this is largely a myth (Dixon 2006). Carlyle certainly once, much earlier, referred to Malthus as dismal, but the expression 'dismal science' arose in the context of an attack on the ideas of John Stuart Mill and others in an essay in support of the reintroduction of slavery (and what was dismal about economists was that they regarded all humans as equal and did not distinguish between races). 'Dismal science' as the term for economics was in distinction to what was then known as 'gay science' – that is to say - poetry. (In the 21st century 'gay science' might be assumed by the uninformed general reader to have a completely different meaning – such is the evolution of language usage!). Dixon (2006), however, suggests that, despite the first appearance of the expression 'dismal science' being in 1849, Carlyle's opinion of economics had probably developed much earlier and had been influenced by consideration of Malthus.

Throughout the century of ANZAAS (Australian and New Zealand Association for the Advancement of Science) congresses, that body regarded economics as a discipline within science and it was accorded the status of having its own section. Economics is one of the disciplines in which Nobel prizes are awarded; the practice of the discipline, in at least some academic institutions, is rigorously questioning, independent and outcome neutral. All of this speaks to recognition as a science. However, economics as portrayed in much of the media, and recycled by politicians, is regarded by the public with suspicion, and economic modelling in which the assumptions, data, and methodology are explained inadequately, if at all, has become the object of scepticism.

Piketty challenged economics from within the discipline. In the same year Klein (2014), not an economist, presented the case that the modern economic system was fundamentally incompatible with the maintenance of the environment and that the belief that market mechanisms will be able to address the impacts of climate change is false optimism. (This is not a new viewpoint, but Klein's book is one of the fullest accounts of the argument.) This is a more profoundly depressing thesis than Picketty's. Although the book has been extensively reviewed in the media there is little indication that the fundamental changes to the prevailing economic paradigm which Klein argues for are on any political agenda or even that they are likely to receive serious consideration.

Malthusianism

Ideas which, from the perspective of most scientists, become to be accepted as scientifically uncontroversial still give rise to opposition and concern from influential voices in the broader community. Historically this could be seen in the opposition of the Church, the then ruling elite, to astronomers such as Copernicus and Galileo. Slightly more recently the writings of Malthus

(a clergyman) aroused substantial opposition. (Malthus, who rates a mention in almost all general biology texts, was christened Thomas Robert. He is normally referred to in the literature as Thomas. Mayhew (2014) shows, that within his family, he was known as Robert. Lawson (2008) has a bet each way, referring to him in the text as Robert, and in his index as Thomas).

Malthus's *Essay On the Principle of Population* was first published, anonymously, in 1798. Although entitled an essay, it was a substantial piece of work of some 50,000 words. Five years later the essay was reprinted bearing Malthus' name. Subsequent editions grew considerably, the fifth being over 200,000 words. The essay does not mark a paradigm shift in science of itself, but it was important in the development of both Darwin's and Wallace's thinking about the mechanism of evolution. However, over two centuries, later Malthus is still a figure of ridicule to critics. One recent attack was by Aslet (2013) who commenced his article, "Malthus is shaking his hoary locks. The old seer does it every so often, and no amount of being proved wrong will keep him in his coffin", although a few paragraphs further on Aslet changes the argument to "Malthus hasn't been proven wrong; it's simply that he hasn't yet been proved right". The object of Aslet's article was to criticise Sir David Attenborough for arguing that the world is overpopulated.

Malthus can be viewed as a pioneer in predictive modelling, and his model depended on a feedback between population and resources. Resources in Malthus' analysis were food and land. Later in the 19th-century, Jevons (1865) extended the argument to coal, as the essential source of energy driving industrial development – his argument is, however, readily extended to other non-renewable resources. He argued the population was increasing, and use of coal, in the industrialised United Kingdom, was increasing per capita, but coal resources had 'a certain and absolute limit.' The essential argument was to be reiterated by Marshall (1890), who realised the inevitable limited nature of non-renewable resources, but also that their extraction had social and environmental costs. More than a century later the global economy is still based on the extraction and burning of carbon (coal, oil and gas), despite increasing recognition of the environmental and social costs. (Coal extraction has virtually ceased in the United Kingdom, but not because Jevons' (1865) 'absolute limit' has been reached, but because the costs of production make it uncompetitive against cheaper imports.) Recently concerns about peak oil, and predicted declines in future production, have been allayed, at least in the minds of government and business, by the large-scale development of unconventional gas resources (Morse 2014; Hefner 2014), despite the uncertainty over the environmental impacts of utilising these 'new' resources.

Malthus' model did not anticipate advances in agriculture and food technology, so that the global collapse has not yet occurred, although many are starving, and this is the basis of most of the attacks made by his critics, who argue 'Malthus was wrong'. However, it seems to me that the basic mechanism Malthus postulated is difficult to refute and, that without measures to reduce growth in population and consumption there is an inevitability about the ultimate outcome. Aslet (2013) argues that sufficient food can be grown to support the current, and a much larger, human population – if the food were produced efficiently and in the right places. History would suggest that geopolitical realities are likely to prevent such an outcome – but even if he is correct and that the human population could be maintained at much higher levels, there are other questions which society and politicians need to address. If it is possible for the world to support a very much larger human population, would this outcome be desirable given the impacts on quality of life experienced? Is the loss of biodiversity associated with expansion and intensification of agriculture acceptable? Are the costs of providing not just food but also water, waste disposal, transport infrastructure *et cetera* capable of being met? It seems to me that the basis of the continuing criticism of Malthus is that his ideas raise fundamental questions about growth of both populations and economies - growth that is seen as essential for the survival, in their current form, of economic, social and political structures, but which ultimately will result in a collapse of biodiversity and ecological services. If Malthus were indeed wrong, then it is curious that critics so frequently see the need to proclaim it, thus giving him the continuing oxygen of publicity.

Malthus was also amongst the pioneers of the exploitation of big data, in that the source of his information on births and deaths was from parish records. He was not the first to mine these sorts of information. Graunt in 1662 had published his *Natural and political observations made upon the Bills of Mortality* (see Benjamin 1964) which analyses the causes of death recorded for London in considerable detail, with important discussions on the difficulties of reliable attribution of causes of death. His paper includes a first attempt at constructing a life-table, and can thus be regarded as one of the foundations of demography and the actuarial profession. Despite the Romans having introduced censuses (as we are reminded at Christmas) there was across Europe in the 18th century no collection of population data on a national scale. Malthus recognised the limitations of parish-based data and advocated strongly for the introduction of a national census, but it was to be 1841 before the first British census was conducted.

Malthus developed his ideas at a time of political ferment across the Channel, when the population of France was greater than that in Britain and its agriculture in a less favourable state (Mayhew 2014; Piketty 2014), and it was in France that he anticipated the feedback between population and resources would be soon manifest. In Britain, as the Industrial Revolution continued, urban areas expanded rapidly and the nation was one of, if not

the first, in which the urban population exceeded the rural – a condition not reached globally until the early 21st century. However, at least in its early stages, the expanding towns and cities experienced much higher mortality and lower life expectancy than the countryside.

Mayhew (2014) shows that Malthus remained a major influence on economic and political thought throughout the 19th and 20th centuries, despite regular attempts at debunking him from both the Right and the Left (Marx was a particularly strong opponent, seeing in Malthus' mechanistic model no opportunity for the working classes to better themselves). He also discusses how in the 1960s and 1970s Malthus became a major influence on the emerging environmental movement, first in the United States and then more widely. Malthusian ideas have also continued to influence demographic studies in wildlife populations (see for example Lunney *et al.* 2008). Mayhew (2014) also makes the observation that the figure whom he regards as 'the doomsaying doyen of the new Malthusianism'– Paul Ehrlich – curiously did not mention Malthus at all in his 1968 book *The population bomb*, and that other key writers in the period similarly made little direct reference to Malthus, for all that their arguments were restatements of Malthus' principal theses. The environmental movement, then, as now, attracted strong opposition from some sections of the media, and the critics at least had no doubt that the environmental movement had an intellectual base in Malthusianism; the purported failures of Malthus' predictions being sufficient to damn environmentalism. The new Malthusianism of the environmental age differed from the original in its strong advocacy of zero population growth, to be achieved through contraception. Malthus was an opponent of contraception *per se*, although strongly supporting indirect methods of regulating population growth, most particularly a late age of marriage.

The debate about the relevance of Malthus' ideas continues, as shown recently in the debate between members of the Royal Society (of London)- see Ehrlich and Ehrlich (2013a, b) and Kelly (2013); the two sides are unlikely ever to agree.

Evolution

The theory of evolution is regarded as extremely dangerous by some sections of society, but this was not always the case.

The theory of evolution represented a major paradigm shift in biology, although curiously it is not listed as one of the examples of a paradigm shift in the Wikipedia entry on the subject- although plate tectonics and Mendelism are (Paradigm Shift - Wikipedia, last viewed 16 March 2016. By citing Wikipedia I am not suggesting that it is an authoritative source on the topic - rather it illustrates that minds might differ over what constitutes a paradigm shift.)

The theory of evolution rapidly became mainstream in biology and related fields such as palaeontology (notwithstanding that notable palaeontologists, such as Richard Owen in England and Louis Agassiz in the United States, remained resolute opponents of Darwin – Agassiz for religious reasons and Owen, given that he certainly entertained evolutionary ideas, for more complex reasons).

The publication of *On the Origin of Species by Means of Natural Selection* in 1859 gave rise to controversy but it was relatively short lived. Bishop Wilberforce was at the time the leader of opposition, but the very broad Church of England (including amongst its clergy many leading natural historians) was, as an institution, not an opponent. Benjamin Disraeli was not a supporter of the theory of evolution, but on the whole politicians of the day were not participants in the debate. Darwin, on his death, was included amongst the great and the good by being buried in Westminster Abbey. The Roman Catholic Church at the institutional level was never opposed, and at various times has actively resisted the exclusion of evolution from school curricula.

Origin of Species was a bestseller in its day – and, unlike Hawking's (1988) *A Brief History of Time* in more recent years, was both read and understood by most purchasers. For much of the population in the late 19th century, the theory of evolution was not seen as dangerous or a threat; natural selection indeed could be used to justify the booming capitalism of the industrialising Western world.

Today the growth of Christian fundamentalist sects has been accompanied by an increasingly anti-evolution creationist sentiment in sections of society (see Calver, 2016). To creationists, the theory of evolution is a dangerous idea; to scientists and to society more broadly creationism is, of itself, not dangerous (Brooks 2012) (although we might regard creationists as misguided or wrong in their beliefs), but what is dangerous is the attempt by some creationists to demand their beliefs (sometimes hiding under a veneer of respectability as intelligent design, see Bridgstock 2012) be taught as science, and teaching of evolutionary science be suppressed (suggesting to those arguing this view that they are no different from Stalin during the Lysenko era can generate interesting discussion!).

The growth of anti-evolutionism is a worrying trend because it is accompanied by a more general anti-science sentiment, expressed in, for example, movements opposed to vaccination or fluoridation. Holders of these views demonstrably misunderstand or distort science, and their successes pose risks to the rest of society.

Scientists won the initial fight for acceptance of the theory of evolution, and, with support from scientists, practices such as vaccination were rapidly adopted as part of national public health policies, but scientists have

not been conspicuous (at least as reported in the media) in opposition to the new anti-science trends. Unlike Calver (2016) I am unconvinced that attempting to seek accommodation with creationists (and by extension anti vaccination or anti fluoridation activists) is an appropriate response.

Mendelian genetics represented another paradigm shift, but an unusual one in that Mendel's work remained unknown by the wider scientific world for several decades after its original publication. When Mendel's work was rediscovered it was initially believed that the new genetics were incompatible with Darwin's theory of evolution and it took until the early decades of the 20th century before synthesis of evolutionary theory and genetics was achieved (Huxley 1942).

The Crick-Watson elucidation of the structure of DNA was a major scientific achievement but was not a paradigm shift; it was the culmination of a search for the chemical basis of genes that had been underway for many years (Whitehouse 1969). The breakthrough that enabled the structure of DNA to be discovered was the development of X-ray crystallography. The realisation of the implications of the structure for how genes work was what led to the development of molecular genetics, which remains a rapidly growing area of science. While some of the ideas about the possible uses of genetics are dangerous to society (for example eugenics – which is also 'bad' science), the science of genetics in itself is neither dangerous nor unexpected.

Climate change

The concept of climate change, or, more particularly anthropogenic climate change, is to certain sections of the media, business and politics a very dangerous idea.

Amongst scientists and historians alike there would be little, if any, opposition to the notion of climate change (see, for example, Lunney and Hutchings 2012, among a great many publications). The empirical evidence, from a range of temporal scales, is irrefutable. That climate change can have profound effects on the course of human history is also well established and accepted (see, for example, Parker 2013). The pattern of climate change over history provides no reason to expect that climate change will not continue into the future. Climate change should not be controversial; what is controversial is that human activity could cause climate change.

The mechanisms by which changes in the composition of the atmosphere could affect global climate were suggested in the 19th century and are relatively straightforward physical chemistry. However, what those scientists who are the severest critics of the concept of anthropogenic climate change argue is that the magnitude of the possible anthropogenic component of climate change is small compared with that resulting from other ('natural') drivers of climate change and/or that there is no detectable evidence of human influence on climate, at least as yet. The prominent non-scientific opposition to the concept of anthropogenic climate change is based on recognising that if the climate change model is correct, and if society does not wish to experience the consequences, then economies and industrial society will have to undergo profound and rapid change. The concept of anthropogenic climate change is thus dangerous to powerful and influential forces.

It is true that anthropogenic climate change is only one of the possible drivers of climate change, but it is the one which, at present, appears to be inducing more rapid change than any other, and it is the only one which humans have the power to influence.

Some opponents of taking action on climate change do so on the basis that increasing carbon dioxide in the atmosphere will increase plant productivity, and that the climate change will be favourable to humans. The idea that increased carbon dioxide will have a fertiliser effect which will be of undoubted benefit to humankind is a dangerously simple idea, but one that is widely held. Unlike other changes which can be predicted as consequences of increased carbon dioxide, the effects on plant physiology are readily amenable to experimental evaluation. Not all plants will respond to increasing carbon dioxide in the same way or to the same extent so that changes in relative dominance of species can be anticipated, as can changes in foliage nitrogen levels, which make the overall consequences of change difficult to predict. Recent research has shown that raised carbon dioxide levels will impact not just the nitrogen levels within plants, but mineral nutrient concentrations in a range of crop plants. The nutritive value of major foodstuffs is likely, in the future, to be lower than it is at present (Giri *et al.* 2016), with major implications for human well-being.

The optimism that climate change would be good for us is at best only a short-term prediction; if greenhouse gas concentrations continue to rise, then climate will change to conditions outside the human comfort zone. In addition, focus on the climate change consequences of increasing carbon dioxide ignores the effects on ocean acidification (Ross and Adam 2013).

The attacks by some elements of the media (Lunney 2012) and some politicians on climate science and climate scientists have slowed the implementation of measures to reduce emissions and confused the wider public. I am concerned that they may also have inhibited normal discourse among scientists. There are many aspects of possible future climate disruption which are far from certain; and in many areas further modelling and hypothesis testing will be required. However, rigorous debate on such matters may be tempered by fear that public discussion may be seized upon by the anti-climate change fundamentalists as indicating that science does

not support climate change. The media refers to anti-climate change activists as 'sceptics' – this misconceives the role of scepticism in science and misapplies the term to the anti-climate lobby –most so-called climate sceptics are not open to evidence which would challenge their views, but have fixed minds.

The problems of models

Many of the ideas which are regarded as dangerous to establish mindsets are derived from models, and it is at least partly because they are model based that they are regarded as wrong and dangerous. There are many different sorts of models, many of which have had a long history in science and related fields. Today, when the word model is used in science, it generally refers to mathematical models, and to the wider, maths averse public, there is immediately a reason for suspicion. However, there is also a tradition of physical analogue models.

When Port Botany was developed in the 1970s, much of the planning and design work was informed by results from a very large physical model of the northern part of Botany Bay. This was housed in a large building in the north-west corner of the Bay, and survived until subsequently obliterated by the construction of the third runway at Kingsford Smith airport. Many other large coastal and river engineering projects around the world were supported by large physical models, in the same way that the designs of ships and aircraft were tested in tanks or wind tunnels. In the case of coasts and rivers, landforms could be constructed to scale, but sediments could not easily be scaled (sandbanks could be constructed in the model in the correct position and with the appropriate shape, the particle size of the sand in the model could not similarly be reduced in size compared with the original – from empirical evidence, however, this could be taken into account). The Port Botany model did not cover the whole of the Bay, from the point of view of the future operations of the Port it was the northern part of the Bay which was of concern – the southern shores of the Bay were not relevant, although from an ecological perspective they were important. It was not that the model failed to predict changes to Towra Point and its associated wetlands, but that it could not, as they were beyond the model's boundaries. This should sound a warning to all modellers, be they using physical or mathematical models. We need to carefully define the scope of questions to be addressed, and then ensure that whatever models are used are fit for purpose.

Mathematical models have a long history, the simple equations of Malthus, for example, constitute a model.

Mathematical models have at least one of the properties of being descriptive, mechanistic, or predictive. The models of energy and material flows through ecosystems, the production of which was one of the core components of the International Biological Program and which feature so heavily in Odum's (1971) very influential textbook, are descriptive models, although in some cases 'boxes' within the model contain mechanistic components derived from understanding of physiological processes. At the time they were produced they were discussed as being a major scientific breakthrough, involving use of the then very new (and by modern standards, very feeble, for all that they occupied whole rooms) computers, but essentially they were another way of describing ecosystems but in terms of functions and processes rather than the traditional species composition. Traditional ecologists (and the wider public) might have had doubts about treating, for example, all primary producers as one box in a model, but the models *per se* were not regarded as dangerous or even particularly challenging.

When it comes to climate change, while some can be studied using classical experimental manipulation (such as the effects of increased carbon dioxide and temperature on plant species), this is not possible at large spatial and temporal scales (even if the costs and ethical issues could be addressed, there is the insurmountable problem of there being only one Earth, so replication could not be possible).

Exploring and predicting climate change at the global scale can only be on the basis of models, with limited input from experimental studies which are necessarily constrained in space and time, and informed by understanding of past climate and environmental changes. Experiments at the global scale are conducted by changing variable parameters in the model and prediction is assessed against past events, or by the achievement of particular milestones (for example reported recent changes in the distribution and phenology of species, while not proving climate change, are consistent with predictions from climate change models). However, the future does not necessarily have analogues in the past – the levels of carbon dioxide in the atmosphere likely to be reached within a few decades will be far higher than any ever experience by most of the current biota (even if in the more distant geological past, with very different species assemblages, there may have been much higher levels of carbon dioxide), so that we cannot be certain what the responses of the biosphere will be.

Modelling the future will continue to undergo refinement, but even in its present state cannot be dismissed as mere fantasy. The very deep distrust shown by large sections of the public and amongst politicians is perhaps one of the most dangerous challenges to science in the present day. Unless it can be overcome, the prospects for effective responses to many of the most serious issues facing humankind and the biosphere are slim. The view that models are intrinsically wrong is held by people who nevertheless are comfortable travelling in aircraft, for all that many aspects of modern are designed and developed through computer models. Scepticism about some models

in other circumstances perhaps has more foundation, cost - benefit analyses for major developments and traffic modelling both empirically and anecdotally frequently fail to live up to expectation when the development proceeds.

Ideas from outside science

Scientific paradigms can be challenged by lateral thinkers from disciplines outside science, and this can be extremely beneficial to the development of science but there are potential dangers if those promoting new ideas either fail to adequately assess the science which they are challenging, or assume that a scientific approach is irrelevant.

I examine this issue through an in-depth analysis of some issues in environmental history.

Historical truths?

The past is a foreign country;
they do things differently there.
L.P. Hartley (1953). The Go-between

"Those who cannot remember the past are condemned to repeat it" is an aphorism attributed to Santayana (1905). A simple Google search reveals that it is frequently quoted as paraphrase or is misquoted ('He' instead of 'those' for example). The underlying sentiment can be found in the writings of many earlier authors, while another twentieth century coiner of aphorisms on an industrial scale, GK Chesterton, wrote "The disadvantage of men not knowing the past is that they do not know the present."

In the context of the forum the sentiment could be expressed as – if our understanding of history is faulty, then applying that understanding to current problems is likely to lead us astray.

Understanding history is fundamental to cultural and social identity. Contrary to the belief held by many that history, and historical interpretations, are absolute there is scope for differences of opinion and variation in interpretation. The facts of history are essential, but mere recitation of names, dates and events is antiquarianism rather than history. The facts have to be evaluated, and not all facts of popular history survive assessment, but even when the facts are confirmed, their interpretation often requires the skills of historians. Interpretations may be revised in response to the discovery of new facts, or even when the factual basis is unaltered, perceptions and values may change.

History can be approached scientifically, and expressed as competing hypotheses amenable to testing through access to primary records. In some areas of history, such as economic or social history, data are amenable to statistical evaluation (Floud 1979). However, much of the history beloved of politicians seeking to impose rigour on the school curriculum contains a high proportion of myths. Currently, as various nations are engaged in marking the Centenary of the First World War, the need to draw boundaries between myths and history is particularly important.

Myths are culturally important, but if we are to call upon history as a guide to the future, we need to ensure that the myths are recognised and discarded for that purpose.

What is now variously termed environmental or ecological history has long been studied by historical geographers, historians, landscape historians, anthropologists, archaeologists, archaeologists and quaternary palaeoecologists. It is only more recently that ecologists have become heavily engaged with history, although the natural history tradition from its earliest days often involved antiquarian interests. The focus of environmental histories may be local areas (Rackham 1989) whole nations (Hoskins 1955) specific ecosystems (Griffiths 2001; Rackham 2006,), individual species (Salaman 1949; Sheail 1971) or particular issues (Lovegrove 2007). Increasingly, historical interpretations are used to advocate for, guide or justify contemporary practices of ecosystem management. While I see this as a valuable trend it is not one without dangers, as I discuss below.

Fire management – the constant battleground

Fire is an important, and often controversial, factor in Australian land management. Recently, considerable interest has been ignited by the publication by Gammage (2011c) of *The Biggest Estate on Earth*. This book attracted glowing reviews, and garnered several major literary prizes.

The central thesis advanced by Gammage in a series of papers (Gammage 2005, 2008, 2011a, b, before the greatly expanded synthesis in Gammage 2011c) is that the Aboriginal people had developed a complex system of land management, applied across the whole continent, with fire as the major tool to achieve management objectives, and, "Once Aboriginal people were no longer able to attend their country it became overgrown and vulnerable to the highly damaging bushfires we now experience." In view of the boldness of Gammage's claims, and the implications of his conclusions, it is appropriate to examine the evidence in some detail. (The audience at the forum were made aware of bushfires when, at the start of my presentation, it was necessary to evacuate the Australian Museum, when the pall of smoke from major bushfires in the Blue Mountains blanketing the city set off smoke detectors and fire alarms.)

Gammage's book is based on three propositions about the continent in 1788:

1. Unlike the Britain of most early observers, about 70% of Australia's plants need or tolerate fire. Knowing

which plants welcome fire, and when and how much, was critical to managing land. Plants could then be burned and not burnt in patterns, so that post-fire regeneration could situate and move grazing animals predictably by selectively locating the feed and shelter they prefer.

2. Grazing animals could be shepherded in this way because apart from humans they had no serious predators. Only in Australia was this so.

3. There was no wilderness. The Law – an ecological philosophy in force by religious sanction – compelled people to care for all the country. People lived and died to ensure this.

The Law prescribed that people leave the world as they found it. 1788 practice was therefore conservative, but this did not impose static means. On the contrary, and uncertain climate and nature's restless cycles demanded myriad practices shaped and varied by local conditions. Management was active not passive, alert to season and circumstance, committed to a balance of life.

Law throughout the book is spelt with a capital 'L' – in the same way that in Western writing God (and references to God such as He, Him, and the Almighty) have traditionally been capitalised.

It is central to Gammage's argument that there was one Law, from the east coast to the west coast, from the Top End to Tasmania – which together form a single 'estate.'

In giving effect to the Law "The chief ally was fire".

Gammage believes that "almost everyone accepts that in 1788 people burnt random patches to hunt and lure game". There is recognition of the reality of Aboriginal burning, but I am not sure that this acceptance assumes that burning was random – Gammage, I feel, draws a false distinction between his view and that held by many scholars (in a range of disciplines) for a long period

My impression derived from decades of discussions on fire is that it is widely accepted that the burning was directed, based on an understanding of the environment, and was not merely random or haphazard. The real difference of opinion is about the extent and universality of Aboriginal burning. Gammage suggests that Aboriginal burning involved "no haphazard mosaic making, but a planned, precise, fine-grained local caring. Random fire simply moves people's guesses about game around the country. Effective burning on the other hand, must be predictable. People needed to burn and not burn, and plan and space fires appropriately. Of course how a pattern was made varied according to rain or climate: heath, rainforest and Spinifex each require different fire. Yet in each, the several purposes of fire remained essentially the same. A plant needs fire to seed, and animals like a forest edge, a man wants to make a clearing. Means were local, ends universal. Successfully managing such diverse material was an impressive achievement; making from it a single estate was a breathtaking leap of imagination."

It is the reality of this single national estate which is controversial.

The Law, according to Gammage, was underpinned by three rules

- "Ensure that all life flourishes.
- Make plants and animals abundant, convenient and predictable.
- Think universal, act local."

The third of these in particular is very much a 20th century interpretation, even if there was a Law which operated as claimed, I would be surprised if anyone in 1788 – be they Aboriginal or European - would have adopted the green movement '*think global – act local*' mantra of the 1970s.

Gammage utilises three sources of evidence to develop his thesis:

- "writing and art depicting land before Europeans changed it
- anthropological and ecological accounts of Aboriginal societies today, especially in the Centre and north
- what plants tell of their fire history and habitats."

Of these, writing and art are the most extensively discussed. In relation to the second point, Gammage relies on the literature: he has not himself conducted ethnographic, anthropological or ecological studies and his discussion of literature from other disciplines is limited and selective. The third line of evidence is potentially a very important source, which remains to be explored in much more detail.

Every picture tells a story.

Gammage (2011c) restricts his study to European art. He does not address Aboriginal art, either traditional (rock art and dendroglyphs, carved trees - Etheridge 1918) or modern, of which there are several schools (Mclean 2016). Rock art has been important to ecologists in providing evidence of the pre-European distribution of a number of species. The representation of landscape and events in modern indigenous art often involves symbols and is not a pictorial representation in the European tradition. Interpretation requires knowledge often not vouchsafed to non-aboriginals. Indigenous representations of country often employ symbolism which is local (Arthur and Morphy 2005), rather than

there being a single continent wide set of symbols and conventions. I do not know whether a study of Aboriginal art would illuminate fire history, but it is a surprising that the topic is not raised by Gammage.

A substantial part of Gammage's thesis is based on his interpretation of early colonial landscape paintings. He commences the discussion of colonial art thus: "Some critics assume that early colonial artists romanticised their landscapes, making them inaccurate. Certainly artists like John Glover, Eugen von Guerard and Joseph Lycett squeeze scenes horizontally to fit more in, or embellished foregrounds with romantic but transient detail, but this does not make their landscapes inaccurate. Almost all the scenes reproduced here let me or others pinpoint where the artist sat to draw them."

The counter view was expressed by Seddon (1976): "Part of the difficulty with such studies is that it is not always clear what should count as evidence. The only perceptions we know directly are our own. We guess at the perceptions of others from what they say they perceived, what they record, what they admit, how they behave. Poetry, painting, old films, advertisements in newspapers, are all records but they all need interpretation – early pictorial artists drew the indigenous flora and fauna, and topography, Aboriginals, in certain ways, partly because of current traditions of draughtsmanship, and because of the function of their work (e.g. to serve as scientific illustration rather than decorative wall hangings), partly because of individual idiosyncrasy, or limitations of skill with the pen, partly because of cultural preconditioning (which led, for example, to the portrayal of Aboriginals first as noble savages, and a few years later, in reaction, as comic scarecrows) – and partly as a genuine visible response to the object before them. The last component, the only one which some would call the genuinely perceptual component, is not in fact separable from the cultural and biological predisposition to see in certain ways.

If it is hard to interpret individual perceptions, it is harder to make useful statements about those of community."

It is a matter of observation that many landscape paintings (not just Australian ones) depict recognisably the framework of landscape, so that viewers can locate themselves in context, but the perspectives and detail may be modified, distorted or selectively omitted. This is at the core of art – it involves interpretation as well as representation. Different viewers will have different responses to particular works of art – this may be partly instinctive but also involves cultural conditioning, and what is deemed 'good' art in one period may not be so in another.

Gammage considers that because one can locate the vantage point of the artist, and recognise in the work distinctive landscape features then the work as a whole is 'accurate'. He comments on the 'accuracy' of a number of artists he uses to illustrate the book, for example – "Lycett painted under the patronage first of commandant James Morissett at Newcastle, then of Governor Lachlan Macquarie at Sydney. These officials wanted accuracy, to show people at home what Australia was like."

And – "Accuracy is not surprising. Artists were the photographers of their day. Why invent a landscape that viewers might know was false, when the original was so novel? It was safe to embellish a transient foreground, but not the broad span of the land, for along with its people and animals this was the main reason for painting Australia at all."

This is a curious statement as, if the purpose of at least the officially sponsored early art was to show people at home what Australia was like, then the intended audience would have had little option but to take the work at face value, having no way, at the time, of knowing whether it was false. While humans and animals feature in some, but not all, of the artwork, if they were even part of the main reason for painting Australia at all, then the early artists did not perform too well (indeed the humans and animals are part of the transient foreground in most of the works) – mostly what they depicted was flora and vegetation.

I am far from convinced that the photorealistic accuracy was the purpose of the officially sponsored or encouraged art. Rather the government of the day wanted to sell Australia by presenting it in the best possible light by providing images which lived up to some sort of idealised preconception. Smith (1976) the doyen of Australian art historians and critics argued, "The earliest drawings and paintings of Australian towns were made to justify a different point of view all together; to provide evidence of civil progress and good government. Governor Macquarie encouraged Joseph Lycett, the convict artist, to paint townscapes for such purposes and they came clean and precise; tokens of British order in a southern wilderness. I wonder what they really looked like?"

Smith illustrates his position using an image of early Parramatta by Lycett, which shows a model settlement surrounding Government House, set in sweeping grasslands dotted with trees and stands of woodland. This is not one of the Lycett images cited by Gammage, but in general compositional terms is not dissimilar to the images that Gammage uses. There are a very large number of colonial artworks which would be available for study – from professional, semi-professional and amateur artists. Some are well known and catalogued, others remain to be rediscovered, and many, perhaps, have been destroyed. Similar observations could be made about written records. It would be clearly impossible for any investigator to have regard to the complete record; obviously there has to be a selection. Unfortunately Gammage, while acknowledging the situation, does not provide any clear explanation of what guided his choice (and one is left with the

feeling, perhaps unfounded, that the choice is based on those works which provide support for his hypothesis). However, whatever criteria were used it is surprising that Lycett features amongst the chosen. It is hard to see how any claim that he, at least, could be regarded as the photographer of his day (if the analogy is intended to imply that he was the faithful recorder of what he saw).

Joseph Lycett is a fascinating, if shadowy, figure in early colonial history. Unfortunately many aspects of his life remain unknown or contested (McPhee 2006a). He came to Australia as a convict, having been found guilty of forgery. His criminal behaviour persisted and, as punishment, he was sent from Sydney to spend a period in the then isolated settlement of Newcastle. Because of his skills, both Morriset, the commandant in Newcastle, and later, on his return to Sydney, the Governor, Lachlan Macquarie and other colonial officials commissioned work from him.

Lycett was extremely prolific, but his best-known work is the *Views in Australia*, published in London in monthly parts from September 1824 to June 1825 – each part containing two prints of New South Wales and two of Van Diemen's Land (MacPhee 2006a). These were intended by his backers to be, in essence, an illustrated prospectus to encourage settlement in Australia. The work can be considered almost as a set of postcards, or like the real estate pages of today's weekly local newspaper – images which are not 'wrong' but certainly, as Smith (1976) pointed out, designed to show the colony in its best light. Counting against considering Lycett as an equivalent to a photographer of his day is the fact that, in all probability, he never visited some of the sites which he illustrated, particularly Tasmania (Van Diemen's Land) and Lake George (McPhee 2006a). This is acknowledged by Gammage (2011c) but not much is made of it. It is assumed that Lycett's images are based on sketches and notes of others, but, although possible sources have been suggested they have not been conclusively identified. Lycett is very likely to have observed Aborigines around Newcastle, but obviously could not have made original observations in places he had not visited. For one of Lycett's well known paintings, one of the relatively few of his works in oils, (*Corroboree at Newcastle* circa 1815) (not one of the images cited by Gammage) McPhee (2006a) makes a good case for it being a composite of observations depicting activities which took place at different times. If one of Lycett's works was a composite, why not others? Could the human interest added to foregrounds, even if individual elements reflect direct observation, be an amalgamation from a variety of times and places?

What is the evidence that Gammage (2011c) finds in the landscapes that reveal Aboriginal use of fire for management of resources? Although Aboriginal camps and campfires appear in a number of the landscapes, only two show a more extensive fire. One is *A Panoramic View of King George's Sound WA1832* by Robert Dale (picture 56 in Gammage 2011c, although only a limited section of the very broad panarama is reproduced) The second is Lycett's *Aborigines using fire to hunt kangaroos* circa 1820 (in some sources given as circa 1821) reproduced as picture 54, and also providing the cover (the same image also appears in Gammage 2005, 2008). This was originally published in London in 1830 in *Drawings of the natives and scenery of Van Diemen's Land*. As already discussed, Lycett never visited Tasmania and the Aborigines depicted are using woomeras, which Aborigines in Tasmania did not. Acknowledging these difficulties, Gammage (2008) suggests "several of his Tasmanian views are on Macquarie's 1821 route. Perhaps he copied this and the Constitution Hill view from drawings by George Evans or James Taylor – after all he was a forger". By 2011 there is no mention of a possible Tasmanian attribution, rather "this is probably near Newcastle" (although no particular location is suggested) "it shows a common template and its use" (Gammage 2011c). The image encompasses all the elements of Gammage's thesis, which possibly explains its choice for the cover. However, of all pictures cited, it is one far from being analogous to a photograph. If the landscape elements were derived from sketches by others, the addition of the Aborigines, which are more than mere foreground interest, could be based on something observed by Lycett (or copied from a work by someone else), or it could be a composition of pure imagination. Whatever, it cannot be a photographic representation of a real event.

Gammage recognises in the landscape what he terms 'templates', which he defines as: "plant communities deliberately associated, distributed, sometimes linked to natural features, and maintained for decades or centuries to prepare country for day-to-day working. Examples are the grassy clearing or playing beside water and ringed by open forest, and alternating grass – forest circuit or sequence designed to rotate when grazing animals fed, and a big open plain with little or no tree cover to deter animals but promote plants. To work well, templates for animals had to be kept suitably apart, but linked into a network ultimately universal."

The use of the term template differs from the use of templet by Southwood (1977) in his Presidential Address to the British Ecological Society, except insofar as Southwood was concerned with variation in conditions in space and time. (Templet was the term used by Southwood, but it is frequently mis-cited or misquoted as template). The use also differs from that of Bonyhady (2000).

As well as showing a fine-grained pattern of patches of different vegetation types, a common feature of the landscapes that figure in Gammage (2011c) is the general openness of the vegetation and lack of dense understorey features which lead to comparisons with the estates of the English gentry. I have not carried out a targeted search for other works of Australian landscape art from the early

colonial period, but I would point to Conrad Martens 1848 painting, in the Mitchell Library collection, *Mount George from the Bathurst Road*, which shows a very dense understorey – Gammage might perhaps suggest that this is too long after the first contact and growth could have occurred since cessation of Aboriginal management, but the date is within the range of the images used by him to support his case.

Many of the images reproduced in Gammage(2011c) show mosaics of grassland and wooded areas, but the wooded areas, even if apparently extensive, are not open, but are depicted as very dense, so the overall effect is not 'park like'. (The cover illustration of Gammage (2011c) shows such dense patches interspersed with patches of grassland.)

The artist at work

Gammage (2011c) does not discuss the processes and practices of the artists responsible for the works he utilised. None of the works would have been completed by the artist painting *en plain air* in the field as this approach was not developed until later in the 19th century. Even when this technique was employed, a completed work would have involved the artist freezing various components in time – light and shade patterns move over the course of the day, clouds change, foliage may move with the breeze, birds may fly in to or out of the scene. A photograph will freeze all of these elements simultaneously, but it is unlikely that a painter could. The artists whose works are utilised by Gammage would have commenced with field sketches or simple water colours, subsequently reworked into completed paintings in a studio, sometimes from a single sketch, in other cases a composite of several. If the work was to be reproduced then it had to be transferred either by engraving onto a metal plate or onto a stone in the case of lithography. The printed version might then be hand coloured, or coloured by superimposition of several coloured prints. In some cases a single artist was responsible for all stages in the process, in others different people were responsible for the different steps. Sometimes the names of all concerned might be known, in other cases the work might be anonymous or only one of the artists in the chain might be known. In the case of published images the date by which they are cited is usually the year the print or lithograph was made, which may have been many years after the date of the original sketch. Even if the final work is a one-off painting a number of sketches may have contributed to the work, and the date of the painting may be long after that of the sketch. John Glover, for example, was still producing paintings of British landscapes (from sketches and/or memory) long after he migrated to Tasmania.

As an example of the number of persons who might be involved in a single work consider the aquatint *A view of Sydney Cove, New South Wales 1804*, number 34 in the Beat Knoblauch collection which is discussed by Hunt (2007). The original drawing was probably produced in New South Wales by Thomas Watling in about 1800. This original is now lost, but was redrawn by Edward Dayes, and the engraver Frances Jukes made the plate from which the aquatint was made.

Chains such as this obviously provide opportunity for omission, amendment or editing between stages. To pursue Gammage's photographer analogy, then rather than studying the final work it would be preferable to examine the original sketch, the closest to the negative in photography.

That the final work may differ from the sketches is shown by one of Glover's best-known paintings – *Mount Wellington and Hobart Town from Kangaroo Point 1834*. This is instantly recognisable by a viewer as being Mount Wellington seen from across the Derwent, but is it an accurate depiction? Hansen (2003b) points out –

"Obviously, the central motif of the mountain is "wrong"'. Glover has over-emphasised a declivity in the profile of Mount Wellington, reducing its "table mountain" character and pushing forward the nearest tier in such a way that it stands forward of the general mass. Even more apparent is that significant diminution of Mount Nelson on the left of the picture, reduced to less than half its height…."

"Fortunately the relevant sketch books survive and from them it can be concluded that the final work is in fact a composite of three on-the-spot sketches. The key reference is a general outline, a view of the mountain from the eastern shore of the Derwent. This simple line drawing includes the slight crease in the ridge line which the painting exaggerates into a substantial gully. Another sketch shows Kangaroo Bay closer up….. A third sketch, a view of the Sullivan's Cove dock area, has the city and mountains in the background, including the "cut-down" Mount Nelson…"(Hansen 2003b).

So recognisable is the image that I doubt that most observers would question its accuracy. That inaccuracies can be recognised does not argue against the painting being considered a major and significant work of Australian landscape art. It does, however, point to the need not to over interpret detail for other purposes.

Variation between sketches and subsequent engravings are illustrated in the study of late 18th century topographic representations of the English Lake District by Murray (2011). In this case both are also compared with recent photographs taken from as near as possible to the vantage point of the sketcher. In general, the foreground in the sketches is foreshortened so that the peaks and ridges are more prominent than in the photographs which portray a flatter image. Nevertheless the shape of the mountains in the sketches closely matches that of the photographs. The major difference between the sketches

and the photographs is a much greater extent of woody vegetation in the photographs – a trend supported by the documentary record. The engravings are close to the sketches in terms of landscape representation although perhaps cliffs and other outcrops are more dramatised in the etchings, but there are many differences in detail, where the engraver has altered the depiction of people and animals or added totally new material. The works discussed by Murray (2011) are contemporary with early colonial works from Australia and illustrate what was typical (and probably expected) of topographic art of the period, again arguing against over interpretation.

It is likely that much of the human interest in landscape paintings and prints was added on the basis of sketches rather than necessarily being present when the artist sketched the outline of the landscape. Lycett was a keen observer of the local region when he was at Newcastle. He is recognised as an important source of information about Aboriginal culture immediately after the first contact with Europeans (Maynard 2014). Not all his works represent faithful renditions of a single scene. Maynard (2014) discusses one of Lycett works, *An Aboriginal funeral*, and points out the difficulties it presents. The landscape is clearly a view of Sydney, with South Head in the background. However, the Aboriginal people in the image are not native to the Sydney region, but rather are from the Newcastle area. Lycett presumably added the Aboriginal details recorded in his sketches from a different date and different place. Glover similarly is regarded as an accurate observer of Aborigines, but sketches were used as the basis for figures in a variety of pictures, some representing scenes after Aborigines were no longer present in those particular areas. This may make it difficult to determine whether indications of fires in landscapes are in any way related to Aboriginal figures inserted with them.

Amongst the officers and officials in early colonial Australia there was considerable proficiency in sketching. Wilson (2011) points out that the Royal Navy attached such importance to visual records of all parts of the globe that the education of Royal Navy officers included training in scientific and geographical sketching, particularly seascapes and topographic profiles of the coast. Often talent was brought aboard ships from outside the Navy, but a school was also established at Christ's Hospital, as early as 1693 to ensure adequate training. The school still exists but production of naval officers with drawing skills is no longer an educational goal. Ability to sketch landscapes was also a desirable attribute for army officers, useful both in reporting reconnaissance and providing guides for use in battle. Much of the earliest colonial European art in Australia was produced by navy or army officers (or based on their sketches). Skill in sketching is not so widespread across today's population as it was two hundred years ago - but there are still occasions when a simple sketch may be as, or more, informative than a digitally produced image.

Were images created solely through the use of the naked eye? Murray (2011) discusses the use some late 18th-century artists and travellers made of what were termed Claude Glasses (or landscape mirrors) – these consisted of a small plano-convex mirror, on a black or brown foil and bound up like a pocketbook. The user faced away from the view and reflected it over his shoulder in the mirror. The convex mirror turned the panorama into a more compressed view, while the foil altered the tonal range. Gray, whose travel writings were a guide for the subsequent sketching trip by Farrington (Murray 2011), was a user of a Claude Glass. Other aids utilised by artists included the camera obscura (a pinhole camera, but with a lens rather than just a pinhole). It has long been known that the Dutch painter Vermeer employed a camera obscura. The English artist David Hockney (2001) has mounted an extensive argument that use of the camera obscura and camera lucida was common amongst artists from the 15th century onwards. He acknowledges that many artists did not use such devices but nevertheless proposes that the use of lenses established a form of realistic representation which all subsequent artists aspired to even if they were not using aids. The thesis remains controversial and is not one that many art critics accept (see Partner 2002).

Hansen (2003a) refers to the use of Claude Glasses and both the camera obscura and camera lucida as devices used by 'tourists' and documents that both a Claude Glass and camera lucida were used by Glover – his Claude Glass is preserved in the Tasmanian Museum and Art Gallery collection, and notes in his sketchbook indicate use of the camera lucida for preparing some images. Curiously, Staples (2003), after discussing the use of Claude Glasses by others, continues "Glover, for his part, used a camera lucida, which is quite a different proposition, intended to aid accurate transcribing of the proportions of what was seen, rather than causing a distortion", implying that Glover did not use a Claude Glass, despite the existence of Glover's Claude Glass. Staples (2003) also considered that "The final effect of Glover's use of the camera lucida here and elsewhere is actually rather stilted, even if the proportions are more accurate."

Even if some of the early colonial artists used optical devices to capture the outline of landscapes this does not necessarily mean that all the details were similarly recorded 'accurately' when there is abundant evidence that much detail was derived from sketches

The camera lucida used prisms or mirrors to project an image onto paper; the outline could be 'traced' to provide the basis for a subsequent work. The camera lucida was used both to prepare sketches of landscapes and for making representations of microscope slides. The camera lucida was an aid to microscopy used to prepare illustrations for papers and textbooks, in common use until relatively recently, when it was superseded by digital devices. The line drawings of tissues, both plant

and animal, that illustrate Australian school and tertiary textbooks in biology from the early 19th to the late 20th century, were mainly based on camera lucida images - and have led generations of students astray, by encouraging them to think that their own freehand drawings from microscope slides should have the detail and complexity of drawings in textbooks.

Can artists paint trees?

This question was posed by Rackham (2006), and his answer was, on the whole, no.

Landscape paintings may be full of trees and the paintings may provide information on the extent and distribution of tree cover at the landscape scale, but it is frequently difficult to identify, to species, individual trees. Rackham (2006) discusses the painting *Cornard Wood* (circa 1750) by Thomas Gainsborough, generally recognised as one of the great 18th century English landscape artists. The location of the viewpoint can be recognised today (and in this respect the situation is similar to the landscapes discussed by Gammage (2011c)) but the identity of the trees, although painted with great detail, is not readily discernible. Rackham (2006) also points to Constable who, in his sketches made in the field, demonstrated that he could both recognise and depict many kinds of *Ulmus* (elms), a group of considerable taxonomic complexity (Melville 1948) but when it came to trees in landscapes painted in the studio, the identity of the trees is not clear. (There is one strange exception, the painting of *Salisbury Cathedral* (1823) shows the cathedral framed by two trees which are clearly of the form of elm found in East Anglia and not the prevailing form around Salisbury.) A similar phenomenon arises with Lycett. There is a substantial collection of botanical illustrations by him (McPhee 2006b) which are good examples of the genre. However, when it comes to trees in the landscape, I find his depictions problematic – particularly his representations of Casuarinaceae (*Casuarina* and *Allocasuarina*) which have a tendency to look like collections of shaving brushes and on their own are not identifiable to species, although on the basis of habitat and geographical location (making allowance for the fact that Lycett may never have been to locations said to be the subject of a number of images), suggestions can be made as to what the specific identities might be.

Scientific illustrations, of both flora and fauna, remain critical to taxonomic work today, and usually are preferred to photographs. Illustrations have the advantage that the artists can selectively highlight features which are important for classification and identification, and are not constrained by the small depth of focus in close-up photography.

Australian institutions contain extensive holdings of biological illustrations and many more are held overseas. Many artists in the early colony produced technically accurate illustrations many of which are of great beauty as well as being of scientific importance. Hansen and Davies (2014) illustrate a selection of the biological illustrations held by the Royal Society of Tasmania, and similar collections would be present in other libraries, museums and herbaria across the continent (and overseas). The State Library of New South Wales houses the Derby collection of 745 watercolour drawings of flora and fauna from the earliest days of the state's European history, a collection originally made by the natural historian Lambert and subsequently purchased by the 13th Earl of Derby in 1842. The collection was purchased from the 19th Earl of Derby by the State Library in 2011 (Anematt 2014).The animals were mainly drawn from specimens, in the case of birds and mammals often skins. Although recognisable for what they are, fauna drawings often look unnatural because of the way taxidermists of that period prepared and mounted specimens. The floral paintings appear to be much more natural depictions.

John Glover came to Tasmania as a free settler when he was already over 60 years old, and a long established and highly regarded landscape painter in Britain. His *Mills Plains, Ben Lomond, Ben Loder and Ben Nevis in the distance* painted in circa 1832–4 is reproduced as picture 16 in Gammage (2011c). The mountains are clearly recognisable, but Gammage acknowledges that Glover has enlarged Ben Lomond and compressed the view laterally. By 1832 the area would have been occupied by the European pastoralists and their livestock. Glover omitted signs of the European occupation but did include groups of Tasmanian Aborigines in the foreground. Aborigines were absent from this part of Tasmania by 1832. Gammage interprets what he identifies as young gums, wattles and casuarinas in the foreground as indicative of regeneration that had occurred since Aboriginal burning had ceased. The local Aboriginals had been removed from the area from about 1828. Gammage states of these saplings in the foreground vegetation that they are the first generation for decades not to get burnt. If the representation is accurate, and so is the statement that generations of previous seedlings had not reached the same height, then this would imply a fire return interval of around four years – a very short juvenile period in which flowering and seed set must have occurred if regenerative potential was to be maintained over long periods.

The large eucalypt in the left foreground of the painting has rather bizarre contorted branches, as indeed do trees in other Tasmanian works by Glover

Hansen (2003a) argued that "the long supposed "unreality "of Glover's curly limbed trees can be dismissed as something of a furphy. To begin with it must be said that the branches of the Midlands species *Eucalyptus ovata* and *E. pauciflora* do twist and writhe in just this manner. Moreover, Glover's touchstone was empirical observation, and it is possible to trace through his sketchbooks the way he develops an appropriate graphic shorthand for she-oak foliage, or the transition from "on

the spot" record to abstracted form. In fact, paintings such as *View of Mills Plains (cat. no. 69) and Australian landscape with cattle: the artist's property, Patterdale (cat. no. 70)* are quite startling in their verisimilitude…" but Hansen (2003a) also acknowledged that "Glover does distort and simplify, for descriptive affect and pictorial clarity, and quite possibly with allegorical intent, but even with exaggeration the trees retain an element of vegetable portraiture."

I am not convinced by Hansen's defence of Glover's accuracy. I agree that eucalypts and other trees can display curiously distorted shapes, but in those of Glover's paintings that have trees in the foreground as a major focus of the work a very high proportion have contorted, sinuous branches- far more than I would expect if the paintings reflected the occurrence of such forms in the regional vegetation. Trees in the mid- and background of the paintings have much more 'normal' appearance. The distortion of the foreground trees is such that I would be uncertain of their species identity. This does not detract from the paintings as works of art, and I suspect that Hansen's suggestion of allegorical intent may carry some weight - the ' inaccuracy' only becomes an issue if the paintings are interpreted for other purposes.

If there are doubts about the accuracy of representation of trees in the landscape, what of non-trees species? Gammage suggests that von Guerard's accuracy is so well-known that since the 1960s his 1855 *View of Moroit or Tower Hill* (Vic) has been use as a guide to recreate its vegetation. This claim is based on a statement in Youl (2006) that von Guerard' s painting 'was detailed enough for many species to be identified' and the species were used in the deliberate revegetation of Tower Hill. The history of the investigation of the flora of Tower Hill and the restoration of the site is discussed in much greater detail in Bonyhady (2000). The many species identified from von Guerard's painting turns out to be a small number. One of them was a *Xanthorrhea* (grass tree) which J. H. Willis, the senior botanist at the Melbourne Royal Botanic Gardens, found surprising. He did not know whether it occurred on other volcanic areas and wondered whether it could be artistic licence. Bonyhady (2000) notes that "the xanthorrhea was renowned in the mid-nineteenth-century for adding a 'picturesque', even 'oriental' aspect to otherwise monotonous scenery. Von Guerard would have been tempted to introduce it to make the work more interesting." Bonyhady shows how the von Guerard painting provided the template for the restoration project in terms of guiding where planting should occur, however, in terms of a species list, much more was provided from historical records. While certainly some plants can be identified in von Guerard's painting, Gammage (2011c) credits this fact with much greater importance than is probably justified. Most vegetation is relatively species rich (even if one particular layer, such as the canopy, is mono specific) but while in many landscape paintings it is possible to identify some elements of the understorey and ground layer, much of the vegetation is just 'green stuff,' clearly plant but not identifiable to species.

Many environmental histories use landscape paintings and historic photographs as sources of evidence and frequently serendipity is required to find a particular image that reveals a key piece of the story. Nevertheless interpretation of both paintings and photographs must be cognisant of the issues identified by Seddon (1976). I doubt that the accuracy claimed by Gammage (2011c) can be supported.

In addition to information about the vegetation and land use, landscape paintings often include sky. The cloudscapes may sometimes be formulaic or uninformative, but Kington (2010) describes how Constable and Turner both made numerous cloud studies, which in Constable's case were annotated with details of date, time and wind direction and in some cases the cloud type using the then recent classification of clouds by Howard, which is the basis for today's International Cloud Classification. Constable's and Turner's sketches and paintings provide evidence of weather at the time (Bonacina 1937, 1938), information that is important for our understanding of climate change. Thornes (2000) has provided an overview of depictions of weather in European landscape art; what early colonial paintings reveal about weather and climate in the early 19th century is yet to be more fully explored.

The big picture

The landscape paintings discussed by Gammage are interpreted as providing information about Aboriginal fire regimes. Burnt landscapes are not uncommon subjects for more modern landscape paintings (as just one example, Nimmo's *The bush fire's passage* 1952 in the Art Gallery of New South Wales collection). From the 19th century there are three well-known paintings of large-scale bushfires, all from Victoria. Two very large works, Strutt's *Black Thursday, February 6th,1851* and Longstaff's *Gippsland, Sunday Night,Feb.20th,1898* depict the effects of fires on the European colonists. While these paintings acknowledge two of the largest bushfires since European colonisation, they are studio works for which claims of photographic accuracy could not be sustained. Strutt did not directly observe the fire, he was in Melbourne at the time, and his massive work was created after his return to London, where it was first exhibited in 1864. The painting is now at the National Library of Victoria. It is a classical composition, and is full of references and messages. Although a response to the 1851 bushfire it tells us little about the fire itself, but it has been important in generating national sentiment about bushfires. Longstaff's painting is in the National Gallery of Victoria collection. There were extensive fires in the tall sclerophyll forests of Gippsland in the summer of 1897–98. Longstaff visited Gippsland in late February

1898 to observe the fires and to collect material for a major painting. *Sunday night, February 20th* is the result, and was first exhibited in August of the same year.

The third, von Guerard's *Bushfire between Mount Elephant and Timboon, March 1857* (painted in 1859) in the Art Gallery of Ballarat is more interesting for our topic. It depicts a bushfire at night on the Western Plains of Victoria, burning on a very extensive front. Although this is a studio painting, it is based on sketches and the artist's observations at the time of the fire. Whatever the source of ignition, does this fire reflect the burning of the first flush of fuel following the cessation of Aboriginal burning, or were fires on this scale a more frequent occurrence?

Strutt was the subject of an exhibition at the National Library of Australia in 2015 (Jones 2015). One of the revelations (to me at least) of the exhibition was the survival of a large number of sketches by Strutt drawn when he was in Melbourne. Some can be recognized as the basis for parts of subsequent studio paintings, but many remained as sketches. Amongst them are natural history and landscape studies, reflecting careful observation and attention to detail. Of the examples which were in the exhibition none depict fire or templates, but they do provide information about the pre suburbanisation distribution of species and vegetation. They may well be a mine of information for environmental historians.

Today many landscape artists record initial observations as photographs, but many still sketch. Partner (2002) regretted the decline in the teaching of draftsmanship in art colleges, but the art of sketching is not completely lost. Sketches may contain more detail useful for documenting biology and ecology than the subsequent studio work. Heathcote (2016) draws attention to Arthur Boyd's sketchbook which contain details of such things as the feather patterns in bird's wings

Landscape art, and early photographs, are clearly a valid source of evidence for developing environmental histories, but, as with all sources of evidence, must be carefully assessed and evaluated.

Landscape paintings can pose challenges for ecologists. Although unrelated to fire, I am intrigued by Edmund Thomas's 1857 *Entrance to Port Jackson* (reproduced in Hoskins 2009). This shows the Heads and the wreck of the *Dunbar*. However, prominent on a ledge on South Head is a pair of goats. Goats were introduced to Australia with the First Fleet, Goat Island is presumably named because of an association with goats and, prior to the development of the Homebush precinct for the 2000 Olympics, there was a small colony of goats in the brick pit. However, was the inclusion of goats in Thomas' painting artistic licence providing foreground interest, a metaphor or an allegory, a political statement about the failure of the colonial government to 'stop the goats', or were there goats really present at that time? Sea cliffs and headlands on the New South Wales coast, although having general similarity of flora and vegetation, also show considerable variation between sites (Adam *et al.*1989). Some of the variation can be explained by differences in geology, drainage and exposure to sea spray, but could some of the less easily explicable variation relate to differences in grazing pressure from goats? If there is documentation on the past occurrence of goats on coastal headlands, I would be very interested in information about it.

The camera never lies

If artists were primarily illustrators would we have been better served if the camera had been invented a century earlier. Hidden behind the suggestion that landscape artists were the photographers of the day is the belief 'that the camera never lies'. If this implies that the photographs are a faithful representation of the view as would be perceived with the human eye it has probably always been untrue, but is a widely held myth. Perhaps the closest to it was provided by the simplest, non-adjustable cameras like the Box Brownie or the Kodak Instamatic (or more recently by the first generation mobile phone cameras). Even with the simplest cameras, the photographers' choice of viewpoint and the framing and composition of the view may result in images strikingly different from how the average citizen might see the scene as a casual observer. Very early in the history of photography, manipulation and alteration of the image was possible in the darkroom. Today, with digital imagery, the potential scope for manipulation of images is vast. As cameras, particularly lenses, became more sophisticated the image could be influenced before it was captured on film. The photographic or digital image is a very complex thing, whether or not it could ever be called 'accurate' raises issues of both representation and human perception. (Because of the potential for photographs to both inform and mislead, the Land and Environment Court in New South Wales has developed a policy on the use and accompanying documentation of photomontages which may be presented in evidence – the need for observance of the policy forms part of case management directions in pre-trial case management. The NSW DPI provides training in photography for field officers (Honeywood 2012) providing guidance on digital cameras, and how different techniques can influence images.)

Nevertheless, with appropriate caveats and recognition of the limitations of the technology there is a great wealth of information relevant to studying environmental change to be gleaned from old photographs. Unfortunately, many old images have been lost, and more remain unknown or are uncatalogued. Glass negatives in particular provide very high-resolution images. Collections such as the Holttermann collection of photographs by Beaufoy Merlin and Charles Bayliss in the State Library of New South Wales (Cumming 2013) are still to be examined for ecological evidence. Local Councils and local history societies also hold unexplored repositories of old photographic records.

Photographic images can be created through the superimposition of images from different negatives. The resultant composite image can appear convincingly realistic, and the composite origin may be unrecognised by a viewer. The Australian landscape photographer Frank Hurley frequently created composite images, and some of his most famous photographs from the First World War were composites. Hurley considered that he was an artist – during the First World War there was a great disagreement between Hurley and Wilkins, the two Australian official war photographers on the Western Front. Wilkins set out to create an accurate record, and many (but certainly not all) of his photographs are often considered flat and boring, whereas Hurley aimed for dramatic images. Frustrated by an inability to get close enough to the action (remembering that, unlike in later wars, photographers were burdened with heavy glass plate cameras and taking even a single image was time-consuming). Hurley resorted to creating composites, in some cases even using a Wilkins image as the base, and superimposing clouds and bursting shells, or stage re-enactments (Maynard 2015). If ecologists are to use old professional landscape photographs to investigate phenomena like the spread of vegetation over time they need to have knowledge of the photographers' practices. Amateur 'snaps' although less dramatic are also less likely to have involved trickery and so be more useful.

There is no doubt that photographs can be enormously powerful – the importance, nationally and internationally, of the Peter Dombrovskis' photograph *Morning Mist, Rock Island Bend* to the Franklin campaign cannot be disputed. The influence of Ansel Adams' photographs of National Parks in the United States to the American understanding of national identity is considerable. These photographs are undoubtedly works of art – one of Adams early images of Yosemite National Park – *Monolith, the face of Half Dome*, was taken on an occasion when he had only one photographic plate left – Adams (1985) wrote of the result "I have been able to realise a desired image: not the way the subject appeared in reality but how it felt to me and how it must appear in the finished print." The great landscape photographers, as with the great landscape painters, have the ability to evoke the essence of the landscape, and to bring out features which the 'ordinary' observer might miss – but the results are interpretations as much as they are representations. Dombrovskis worked with colour film, but some of the most rewarding landscape photographs are monochrome, where the combination of great depth of field (from use of small apertures), use of filters and skilled printing technique can result in striking images.

The written records

Gammage calls extensively on the written record of colonial officials and explorers and settlers to support his observations

As pointed out by Seddon (1976) and Heathcote (1976), these writings reflect perceptions, preconceptions and ingrained attitudes, and some may have been tailored for the original intended audience. When read 200 years later through the different experiences of today, it is easy to misinterpret the original authors' meaning.

Written European records about Australia extend back to Dutch explorers and, in the north-west, the English privateer, Dampier. For our present purposes, the first key observations were provided by the records of the *Endeavour* voyage. Along the east coast of the continent Cook recorded signs of active fires along the coast – for example on 21 April 1770 off the New South Wales South Coast "in the pm we saw. the smook of fire in several places a certain sign that the Country is inhabited" (http://southseas.nla.gov.au/journals/cook/17700421.html).On the same day, Banks wrote: "Since we have been on the coast we have not observd those large fires which we so frequently saw in the Islands and New Zealand made by the natives in order to clear the ground for cultivation; we thence concluded not much in favour of our future friends" (http://southernseas.nla.gov.au/Journals/banks/17700420. html). (It is interesting that Banks referred to the inhabitants as future friends). It would appear that from out to sea what was observed were numerous, apparently small, columns of smoke; both Cook and Banks assumed that this indicated the presence of humans, and I do not doubt that this was a correct interpretation for some, but not necessarily all, of the observed smoke plumes. Some may have been due to lightning strikes, but assuming that the majority were anthropogenic, when viewed from afar it would not have been possible to distinguish between campfires, signal fires or small-scale patch burning such as required by Gammage's model. Hateley (2010) similarly argued that early travellers' reports of observed smoke and fires in inland Victoria cannot, simply on the basis of the observations, identify the origin and purpose of the fires. Vigilante (2001), in a study of explorers' records from the Kimberley, similarly concludes, '*Explorers were often unable to distinguish between smoke from campfires and smoke from landscape-scale fires.*' Benson and Redpath (1997) were extremely critical of what they saw as a lack of rigour in the interpretation of explorers' accounts referring to observations of smoke (an assessment which is in turn criticised by Gammage (2011c) in his Appendix 1)

Particular difficulties arise with the terminology applied to different types of vegetation. Gammage (2011c) correctly cautions against ecologists assuming that early writers applied terminology consistently or that they were intending the same meaning as is assumed today, but this does mean that interpretation of these early writings is necessarily tinged with uncertainty.

Some of the terms applied to Australian vegetation are perplexing to non-Australians, and why they came to be adopted is uncertain. The general term for Australian

vegetation – bush – is generally assumed to be of South African origin. A South African connection is supported by the similar use of 'bush' to describe vegetated countryside in that nation (in terms such as bush veldt – and fynbos for a sclerophyllous community, analogous to heath in Australia. (Both bosch and bos are Dutch words). The Oxford English Dictionary gives, as one of the meanings of bush – "woodland, country more or less covered with natural wood; applied to the uncleared or untilled districts in the former British Colonies, which are still in a state of nature, or largely so, even though not wooded; and by extension to the country as opposed to the town", and suggests it is probably a direct adoption from the Dutch. This OED definition gives rise to some other queries – what might be meant by 'natural wood' and 'a state of nature'? Cape Town was a replenishment port on the voyage to Australia from England so perhaps the first settlers had some, if only limited, familiarity with South African vegetation. Certainly the term bush, and compound nouns commencing with bush, were recorded very early in colonial times. In New South Wales *State Environmental Planning Policy 19 – bushland in urban areas* explicitly adopts a broad definition of bushland and does not require the presence of woody plants, essentially bushland is used in contrast to built-up areas.

One feature of Australian vegetation terminology which is particularly confusing to overseas readers is the distinction made in Australia between woodland and forest. Today, in Australia the difference is in terms of the density of trees, with forests having denser canopies and woodlands having more widely spaced trees. In England, the designation forest for extensive areas indicates the legal framework for management – they were subject to forest law, but they may have included a range of different types of vegetation. The New Forest includes extensive areas of heathland (although how the British concept of heathland relates to the use of the term in Australia is a different issue – fascinatingly the very first use of heath to describe an Australian vegetation type was by Dampier, on 6 August 1699, who applied the term to describe vegetation at Shark Bay in Western Australia – Spencer 1981), the Forest of Bowland in north-west England has scarcely a tree. Woodlands in Britain are generally relatively limited in spatial extent (patches in the landscape rather than being landscapes in themselves), even though, at least in summer, they have dense canopies.

Gammage (2011c) suggests that the prescriptions Aborigines would have applied in their management would have varied between communities, and not all have been burned with the same frequency, for example heaths and rainforests would have been treated very differently. However, he does not provide any details of the Aboriginal classification of vegetation – how many different types were recognised? Indeed this appears to be a subject about which there is very little information. Only a few Aboriginal terms for vegetation have been taken up into general use – including pindan and kwongan in Western Australia, mallee, mulga and wallum in the East. Pindan applies to both the soil and its associated vegetation, mallee applies to particular species (or group of species), as well as to the community and region in which they are dominant, and wallum applies to a species, a community and a landscape. No Aboriginal term for rainforest appears to have been adopted by settlers, and we do not know how many different types of rainforest were recognized. Within Australia there is a very long history of rainforest (the spelling as a single word is an Australian initiative, but one which has become increasingly international in usage) being given vernacular names such as brush (as in Mungo Brush) or scrub (as in the Big Scrub). The origin of these applications is uncertain (Adam 1992), but the usage reflects the pioneers' difficulties of passage through dense and often tangled rainforest patches, and certainly is not recognition of their biological diversity.

The plant communities recognised in the European literature may have extensive geographical distributions, crossing the territories of several Aboriginal groups. Whether the names co-opted into English were used across the full range of the community, or whether the terms are now used in the same sense as their Aboriginal originators intended, is not clear.

The wallum banksia *Banksia aemula* occurs along the coast from Southern Queensland (Bundaberg) to Sydney. Wallum as a landscape, with a range of communities on sand, is generally regarded as occurring in south-east Queensland and north-east New South Wales (Griffith *et al.* 2003). Heathland stands in which *B. aemula* is either dominant or a conspicuous component occur further south, for example in Bouddi National Park and the endangered Eastern Suburbs Banksia Scrub in Eastern Sydney. Would these southern communities have been given the same Aboriginal name as the communities at the northern limits of the species' range?

Wallum heath is only one of the range of heath types that are conventionally recognised today. Whether Aboriginal vegetation classification was finer or coarser in the European version would be an interesting topic for exploration, and could assist in understanding how Aborigines managed the landscape.

Some of the written records cited by Gammage (2011c) are relatively well known, a large number are probably less well known outside a limited circle of local historians, and an important service which the book provides is bringing the details of the accounts to a wider audience. However, interpretation of the record is not necessarily straight forward.

Macqueen (2013) has made a detailed critique of Gammage's interpretation of the documentary record for the Blue Mountains. (Pointedly, in the notes about the writer at the end of the paper, he states of himself, 'He is not a fire ecologist, but neither is Bill Gammage').

In a number of instances he suggests that Gammage misidentified the location of some of the records, as they were not made in the Blue Mountains (or at least not the Blue Mountains as currently understood).

John Wilson's expedition in 1798 was to the Southern Highlands, around Berrima, which is now mainly farming country, so the landscape today is largely open grassland, and can provide no evidence of any growth of understorey after cessation of Aboriginal burning. If such growth had occurred, any evidence would have been lost when agriculture was developed. Macqueen does not consider that the interpretations of the vegetation encountered by Wilson which were made by Cambage (1920) and Chisholm (1955) are reliable. Chisholm's elucidation of the identity of those accompanying Wilson on his two expeditions provides a lesson on detecting errors which can creep into the record and be perpetuated by successive authors, but Chisholm's successful detective work in this regard does not mean that he was equally 'accurate' in all aspects of his account.

The surveyor William Govett referred to the tops of some of the mountains being open grassy areas. There is evidence from elsewhere that grassy balds may have originated as a result of Aboriginal burning, but by 1831 (when Govett was working in the Mountains), there had been European activity in the Mountains for some years and Macqueen suggests that the clearings could have been created by surveyors.

Gammage also suggested the small cleared area described by the botanist and explorer George Caley was a result of Aboriginal activity. Gammage describes the area as being above the Grosse Valley, but Macqueen suggests it is better described as being on the west side of Mount Tomah South, where there is currently a small area of bare rock that fits Caley's account.

One of the largest treeless areas in the Blue Mountains discussed by Gammage is described as being north of Katoomba, but Macqueen argues that in fact it is Kings Tableland – an area of heathland on shallow soil over sandstone east of Katoomba. Macqueen suggest that it is the environmental conditions that are responsible for the occurrence of heathland, although accepting that Aborigines may have used fire to maintain the heathland in a low state. Macqueen also recognises that there is variation in vegetation associated with the underlying geology, so that vegetation on shale-derived soils differs from that on sandstone, and these differences were noted by early travellers and artists in the Blue Mountains.

Gammage (2011c) refers to an account of Evans of a fire in the Blue Mountains in January 1814, which he interprets as an example of a cool summer fire deliberately lit by Aborigines. Macqueen is sceptical. The fire was very extensive, at least 36 km east – west, scarcely the fine-grained template that Gammage's hypothesis would propose. Macqueen (2013) also suggest that references to Aborigines in Evans account are capable of a number of interpretations, and that Evans does not necessarily imply that he thought Aborigines were responsible for ignition. Macqueen (2013) finds evidence of other large fires in the Blue Mountains – Barrallier noted a large fire in the southern Blue Mountains in December 1802, and Parr observed a very large fire in the Wollemi in November 1817.

Macqueen (2013) does not deny that Aborigines would have managed the vegetation in the Blue Mountains, and that there is ample archaeological evidence of Aboriginal presence throughout the Mountains (Attenbrow 2010). Gammage's thesis may have applied to some or all of the area but the evidence he has adduced is misleading and/or capable of other interpretations. Casting doubt on the hypothesis as applicable in the Blue Mountains does not mean that it may not be valid elsewhere, although such a conclusion would be counter to Gammage's assumption of a single continent-wide Law. However, it will be necessary to appraise critically the whole of the apparently supportive data. (The need for a critical approach applies to any reading of the historical record-not just in relation to fire.)

One Law?

Central to Gammage's (2011c) argument is that there was one Law, applicable across the entire continent, and throughout the time since humans reached Australia, which governed how Aborigines interacted with their environment. As a result of the Law, the Aborigines fashioned an environment which was like the Garden of Eden. This model has recently been subject to critical analysis by Hiscock (2014), on the basis of archaeological and palynological evidence. He points out that since the arrival of humans in Australia – on current evidence around 50,000 years ago in the depths of the last Ice Age – there have been substantial changes to the climate and environment, such that there have been major shifts in the distribution of vegetation types. Such changes will have been direct responses to changing climate, but to the consequences of climate change, such as sea level rise, which will have produced rapid changes in the distribution and extent of coastal resources – such as mangrove forest which provide an abundance of resources. Rising sea levels also covered the connections between the mainland and Tasmania and between Australia and Papua New Guinea

Hiscock (2014) provides examples of rapid changes in the archaeological record suggesting changes in Aboriginal practices in response to environmental change.

The Aboriginal practices which Gammage (2011c) describes from writings in the late 18th and early 19th centuries cannot necessarily be extrapolated back to earlier times.

At the time of European colonisation there was a large number of Aboriginal groupings across the continent, and many language groups. There is evidence for interactions between the groups, in the trade of commodities (for example, pituri-Keogh 2011), the spread of cult ceremonies (Hiscock 2014), and arrangements which permitted members of groups to cross the lands of other peoples (for example the passage to the Bunya Mountains in south-east Queensland to collect and feast upon bunya nuts in fruiting years (Bundock 1898)). However, direct evidence of cooperative management of the continental scale is lacking. Based upon what is known from other continents over long periods of time, expectation of continuous harmony seems unlikely.

Hiscock (2014) is critical of Gammage's (2011c) insistence on a rigid, unchanging law and suggest that the model "effectively dehumanises Aboriginal people and the culture within which they operated by removing any suggestion that they were active agents in their own fate… Gammage represents Aboriginal people as having been without choice, obligated to follow a fixed set of actions as their ancestors always had, and as their belief system dictated".

Hiscock (2014) nevertheless is in complete agreement with Bill Gammage that the ancestors of contemporary Aboriginal people transformed the Australian landscape long before 1788. That transformation was in many parts of the continent probably far more dramatic and less predictable than Gammage has depicted. It was also probably patchier than his story presents. Each kind of landscape would have responded differently to the activities of humans and the action of the humans would have been different in each environment.

To suggest that there was greater flexibility and unpredictability in Aboriginal management is in no way to argue against the importance of Aboriginal law. Before the arrival of Europeans, Aborigines had complex and established laws and practices, and the fact that this legal system was part of a verbal rather than a written tradition in no way lessens its significance or importance. The legal system and its associated religious systems customs and traditions would have had a very strong emphasis on the environment and on interactions with it. Timmy Djawa Burarrwanga, in a prefatory statement to the Report of the Expert Panel (2012) states that the legal system of his people, the Ngarra, holds the "*Yolngu mathematical system about the relationships amongst all people, beings and things in the world – land, sea, water, animals, plants, the wind and the rain and the heavens*".

He also states that "*We Yolgnu have never been anarchists or lawless…*"

This is an appropriate and necessary response to the doctrine of *Terra Nullius* and associated concepts, and Gammage appropriately acknowledges the importance of the Aboriginal legal culture.

The universality of a sense of place

Systems which recognise land, the environment and links to it are probably universal in belief systems globally. Originally these would have been based in communities associated with communal ownership, but it is interesting that the first surviving written record of a legal case in Britain, *Bellicus v Silvanus* in the year 118, involved the sale of a small area of woodland in what is now Kent (Jessel 2011) – when the concept of individual ownership of land had developed in Roman law. Jessel (2011) argues that the change from collective to individual ownership became the most powerful factor leading to landscape change. This was as much the case for Britain with the Roman invasion that it was for Australia and British settlement. As with the Romans, the privileges of land ownership were limited to the upper levels of the social hierarchy. Elements of community ownership continued in parallel with private ownership in Britain for centuries up to the present. Use of commons is often regulated through complicated systems of rules and practice. Jessel's preference for private ownership and the common law possibly reflects a lawyer's view rather than any inherent failing of communal approaches to land management.

At the core of the Aboriginal system is the importance of country and the population's obligations to it. This was, and continues to be, an essential part of Aboriginal identity. However, connection to place is probably universal. Steinberg (2014) records that the North American Indians in what is now New York expressed to the Dutch colonists very similar sentiments to those of Timmy Djawa Burarrwanga. Such a relationship to the land is not unique to indigenous peoples, but can develop relatively quickly among settlers – in Seddon's (1972) memorable phrase 'a sense of place' is of fundamental importance to human society Seddon did not coin the expression 'sense of place' but he certainly gave it new currency and resonance in Australia. Scruton (2012) has approached the issue of attachment to place from the standpoint of philosophy, and discusses at length the German concept of Heimat– a place that is ours, and oikophilia. He argues that the environment is best maintained in those countries where oikophilia is strongly expressed by the population. (Oikophilia is a much broader but related concept to Wilson's (1984) biophilia.) However, Scruton (2012) also recognises a counter strand in society - oikophobia. Oikophobes reject the efforts of environmental NGOs and government agencies and "will in all probability welcome the roads and concrete plazas that plough through the backyards of comfortable people". Some may think that governments are frequently dominated by oikophobes.

Protection of a sense of place may be included as an aim of planning instruments. For example, the Newcastle Local Environmental Plan 2012 includes amongst it aims (cl 1.2 (2))

a. to respect, protect and complement the natural and cultural heritage, the identity and image, and the sense of place of the City of Newcastle,

A Consent Authority is required to take the aims of the Plan into account when making decisions, but the weight to be given to any particular aim will depend on the circumstances of the case at hand.

A consequence of oikophilia is that when the local environment to which a population 'belongs' is destroyed or damaged, people can suffer from a recognised psychoterratic illness, solastalgia (Albrecht 2005; Albrecht *et al.* 2007) – in the Bulga coal mine appeal brought by local residents against the granting of approval to the extension of the Bulga coal mine in the *Hunter Valley (Bulga Milbrodale Progress Association Inc. v Minister for Planning and Infrastructure and Warkworth Mining Limited* [2013] NSWLEC 48) the Land and Environment Court (per Preston CJ) at [420] to [430] recognised that the local residents were experiencing solastalgia as a result of the existing mine (and that this conclusion could validly be made notwithstanding limitations in the survey which had been carried out, involving a self-selected, rather than random, sample of residents).

A sense of place can be invoked or reinforced not only by the place itself but through art, literature and music. Art does not have to be an accurate representation to have this effect, the ability of artists (including photographers) to capture the essence of a locality is sufficient. (I might note that in the case of some old master landscape paintings, buyers might be prepared to contribute more to the purchase of the image than they would contribute to a campaign to conserve the original). Literature contains many fine descriptions of landscapes and place, and there are also many examples where the landscape setting is essential to a novel or poem – the pre-World War I landscape of Norfolk pervades *The Go-between* (Hartley 1953), as does the Australian landscape in *Voss* (White 1957). Changing representations of the Australian landscape in literature are analysed by Kramer (1976). (To move from the sublime to the ridiculous, the success of many series of detective novels relies on their involvement and engagement with particular locations. What might be claimed to be the first spy novel, Erskine Childers' (1903) *Riddle of the Sands* captures to perfection the ever-changing intertidal environment of the Wadden Sea - the film adaptation of which (in 1979) was spoiled for me by the intrusion of *Spartina anglica* into any shot including a saltmarsh – it does not pay to bring an ecologist's eye (or ear – there are many examples of inappropriate bird sounds dubbed on film soundtracks) to the cinema!.)

Particular pieces of music (or particular odours; our links to landscape may be triggered by all the senses) may sharply bring back memories of particular places and events, but music can also paint pictures which are strikingly evocative of the sense of place. In Western music this is particularly obvious with the representations of Finland by Sibelius or in the works of English music in the first decades of the 20th century (such as Butterworth's *On the banks of green willow* or Vaughan Williams' *A lark ascending.)* The importance of music and of art to our understanding of place has been emphasised recently by Sinclair (2016).

The sense of place is a powerful universal feeling in humans, and I agree with Scruton (2012) that it is the root of environmentalism and the conservation movement. Perceptions about particular places differ; we do not all see the world in the same way, but the importance of the local environment underlies what in some quarters is derided as nimbyism– more reasoned argument than mere instant dismissal will be needed from politicians and proponents of major development if they want to bring the public with them (and those who object to local residents' opposition to particular developments are as likely to defend their own property should it be threatened by some other sort of development).

A sense of place may in old cultures have a genetic underpinning (which is not to deny that recent immigrants can rapidly develop a strong link to landscape and nature in their new land). Tobler *et al.* (2017) examined mitochondrial genomes from a large number of historic samples of Aboriginal hair from across Australia, and demonstrated very strong patterns of geographic regional differentiation. The data support invasion from the north about 50,000 years ago, followed by spread by two migration pathways, one clockwise and the other anticlockwise, with the two meeting in south-east Australia. The strong regional groups survived intact through periods of major climatic and cultural change. The authors suggested that the strong links to country shown by different Aboriginal groups reflect the regional retention of these genetically defined population groups. The existence of distinct geographical groupings retained over 50,000 years may argue against the likelihood of there having been one Law.

Ensure that all life flourishes?

Gammage (2011c) claims one of the roles of the Law was ensuring that all life flourishes. Assuming that all life can be treated as a synonym for biodiversity, can it be said that the object of the Law was biodiversity conservation?

It is difficult to know how broad the understanding of what we now call biodiversity was amongst Aborigines. Certainly there had a sophisticated taxonomy which recognised useful plants and animals – extending to some insects, to intertidal invertebrates, and possibly some fungi but, as with the average European, even those living in the countryside, I doubt this extended, even at

high taxonomic levels to most insects, let alone other invertebrate groups. Were other than possibly a small handful of bryophytes and lichens distinguished?

Although there might not have been specific identification of a large proportion of the biota, did the approach to country have the consequence of extending a protective umbrella to all of what we would now term biodiversity?

Gammage implies that the impact of Aborigines on the environment was relatively light. One question is whether this was a deliberate intent or a consequence of a small population and limited capacity to impact on the environment? Gammage (2005) states "the Law demanded the continuance of every form of life: plant, animal, insect and what Westerners know as inert forms such as fire, water, wind and earth. Each lifeform had a totem, and via this each was inextricably one with the people of that totem, who had a particular but not exclusive responsibility to ensure that it flourished. The great changes which Aborigines made to the land had nonetheless to ensure that no habitat was too much reduced, no totem put to risk. For each plant species Aborigines maintained a habitat – grassland for tubers, wetlands for reeds and rushes, and so on. For most animal species they made edges between different plant habitats, since many animals feed in one habitat and shelter in another. Kangaroos, for example feed on grassland and shelter in open forest, both being habitats where they can move quickly if necessary. So whether on the central Australian plains or the Tasmanian high country, Aborigines put grassland next to open forest, knowing that kangaroos would live along the edges".

As Low (2014) observed that, in relation to Gammage (2011c), the writing is beguiling. It presents a romantic story which the reader might wish to be true, but for which reliable supporting evidence is sparse. It involves an interpretation of what is assumed to have been the nature of the landscape at one point in time (1788) and extrapolating back over some 50,000 years. Such records as do exist have limited temporal and spatial resolution, and at best only provide data for a tiny fraction of the total number of species. There is also an apparent paradox in acknowledging, on the one hand, that Aborigines had made 'great changes' to the land, and yet, on the other hand, implying that every form of life had not suffered serious consequences a result of the changes. The separation of animal from insect is biologically bizarre, but is widespread in general use, and is even embraced in various pieces of legislation – but I cannot be sure that the formulation 'plant, animal, insect' is intended to cover every form of life. Neither would I refer to fire, water, wind and earth (being the four 'elements' of the ancient Greeks, although 'wind' is normally referred to as air) as inert.

Lightning

Prior to the arrival of Aborigines in Australia, about 50,000 years ago, the vegetation contained the vast majority of species currently present, those species regarded as fire tolerant would have had the various features which enable them to survive bushfires. Without entering into the debate over whether these features were exaptations[1] (Bradshaw *et al.* 2011) or evolved uniquely under the selection pressures of fire, the vegetation undoubtedly burned, and lightning was the ignition factor.

In recent years there has been an increasing recognition of the long geological history of the role of fire in the evolution of plants (Keeley *et al.* 2011, Hill and Jordan 2016, Carpenter *et al.* 2016, Pausas, Keeley and Schwilk 2017). The vegetation of Australia when Aborigines arrived was already well adapted to fire (Hill and Jordan 2016), the use of fire as a management tool was not a radical change to the environment (Low 2014) nor a new and transforming element. Rather it represented a tuning of the then existing regime. While it is likely that there were local changes, there is unlikely to have been continent wide changes: this interpretation would be compatible with Mooney *et al.*'s (2011) suggestion that through the late Quaternary period, climate change was the main driver of vegetation change and not humans.

Gammage (2011c) does not question that prior to the arrival of Aborigines the flora was fire adapted, but states that, *there is no evidence that lightning caused most bushfires in 1788*. He also stresses that the incidence of lightning strikes today is low. He suggests that compared with today *the incidence of lightning fire was even lower in 1788, because people set so many fires then, leaving less fuel for lightning to ignite*. If, as Gammage's model requires, much of the country was subject to fire regimes imposed by the Aborigines, then there might have been a lower incidence of fires spreading from lightning strikes, because of low fuel load, but how the incidence of lightning strikes *per se* would have been reduced is not obvious. Gammage (2011c) continues *if lightning fire distributed Australia's plants outside towns and farms the distribution pattern should be similar now and in 1788. It is not*. It is not clear, at least to me, what is meant by the *distribution pattern*. I am unaware of any evidence to suggest large-scale changes in the geographic distribution of individual species since 1788. At the local scale there have been changes in the distribution of communities (for example local expansion of rainforest) but not wholesale movement. Within particular vegetation types at particular localities there have been changes to aspects of composition (including some species becoming extinct and others more abundant) or structure - such as thickening of understoreys. Some of these changes may relate to changes in fire regime, others may be unrelated to fire. The basis for categorical denial of the similarity of distribution patterns in 1788 and now is without supporting evidence.

1 Exaptation is a term introduced by S.J. Gould (see Gould and Vrba 1982; Buss *et al.* 1998). It is essentially synonymous with the older term pre-adaptation. Its use avoids the teleological overtones which Gould thought were associated with use of pre-adaptation. Exaptation has not been widely adopted but has recently begun to appear in literature from West Australia.

Lightning has frequently been downplayed as a cause of fires, Keeley and Bond (2001) suggest that one reason for this failure to recognise lightning as a cause of fires is that there is often a time delay before the fire is noticed. Where there are statistics on the incidence of lightning strikes, comparisons of frequency are unhelpful if they do not also take into account the size and nature of any subsequent fire. (Lighting is often accompanied by rain which might reduce the potential for fire, but there is abundant evidence for the occurrence, even if rarely, of lightning strikes causing fire.) Data from Victoria on causes and extent of bushfires (reproduced in Adams and Attiwill 2011), apparently for the 1970s –1990s, indicate that lightning was responsible for 26% of ignitions and importantly, nearly half (46%) of the area burnt each year. These data suggest a different interpretation of the continuing importance of lightning to that presented by Gammage (2011c).The extensive fires in Tasmania in early 2016 largely arose from lightning strikes.

Even in New Zealand where the landscape was fire prone, but the vegetation was not fire adapted, there is evidence of rare (millennial) forest fires before the arrival of the Maori (about 800 years ago) (Perry *et al.* 2014). Keeley and Bond (2001) point out that it is unnecessary to assume that ignition has to be frequent to lead to the evolution and maintenance of fire tolerant vegetation, but that relatively infrequent lightning ignitions could establish a long-term fire cycle. In the Australian context the 200 or so year fire driven regeneration cycle for mountain ash forests in south-east Australia (Adams and Attiwill 2011) could have been driven by lightning – indeed it is difficult to imagine any other cause.

Under present conditions, lightning is a continuing source of ignition of bushfires, more so in some localities more so than in others, even though large numbers of fires are clearly either accidentally or deliberately caused by human activity. From circa 50,000 years ago to 1788, lightning would similarly have been one of the causes of ignition, and was possibly the major source of ignition in some vegetation types and in regions where Aboriginal activity was lower. We can only speculate, but the assumption of a very limited role of lightning strikes under Aboriginal fire regimes is also speculation.

Catastrophic fire

Gammage (2011b,c) claims that as a consequence of their management of the landscape, Aborigines did not experience catastrophic fire. Implicitly attached to this claim is a further claim that if this pre-1788 burning regime had continued then catastrophic (i.e. very high intensity) files would not occur today. This further invites the conclusion that if practices similar to those of the past were reintroduced then they would reduce the potential for high-intensity fires today. Gammage (2011b) suggests *We must burn more, more often, more selectively. We must get use to black hills. We must ally with fire, welcome it into our heads and language.*

The incidence of high-intensity fires has raised concern in several parts of the world including Australia and there is major controversy as to whether there has been a real increase in such fires in recent decades, and if so, what the increase might be attributed to, and how the consequences may best be managed. These are important issues which will continue to generate fierce debate. However, what was the situation prior to 1788; can it be determined that between the arrival of humans on the continent and 1788 no extensive, human, life threatening high-intensity fires had occurred?

The fire record does not readily provide sufficient resolution (spatially or temporally) to identify individual fires, the likely intensity or their individual extent. However, when humans first arrived on a new continent with a new biota and vegetation different in many respects from that elsewhere on the globe, landscape management must have involved a strong trial and error component, and it is reasonable to suggest that this phase must have resulted in at least some major conflagrations. Acknowledging that Aborigines became skilled users of fire, I find it difficult to imagine that mistakes or accidents were unknown (even if they were rare); escapes from campfires, or changing weather conditions during patch burns could have led to fires burning over large areas. The ecology and distribution of key plants also strongly indicates the occurrence of some extensive, and because of the nature of the fuel, high-intensity fires. In south-east Australia, Mountain Ash *Eucalyptus regnans* regenerates from seed shed from capsules in the canopy after fire, unlike many other eucalypts, there is no post-fire resprouting. Because of the impact of fire in mountain ash forests, their importance ecologically and commercially, their role in catchment protection and the fact that they are the tallest forests in the world, the tall forests in Victoria and Tasmania are probably amongst the most studied in the world. The fire ecology of *Eucalyptus regnans* has been reviewed by Ashton (1976) and Lindenmayer *et al.* (2015).

In the absence of fire, regeneration of mountain ash is limited (Ashton 1976). Natural disturbance (primarily by fire) in mountain ash forests is highly variable in space and time. Regeneration requires seed to be present in a canopy seed bank, with the juvenile period between germination and first seed production being about 20 years. For *Eucalyptus regnans* to have been present in the landscape in 1788, the return fire interval imposed by Aboriginal burning, if they included mountain ash forests in their prescription, would have to have been 20 years or longer. Seed production declines as trees age and local extinction is likely to occur if the interval between fires is less than 20 years or more than 350 – 500 years (the senescent period in which seed production has ceased), unless there is an input of seeds from adjacent areas. Notwithstanding the great height of *E. regnans* trees, the majority of seeds are likely to fall within one tree height (circa 75 m) of the parent. Chance, long-distance dispersal would not permit the

regeneration of monospecific stands. Most capsules absciss or dehisce, or fall attached to twigs, within three years of maturity, but as the seeds fall into areas with a dense understorey, this does not result in successful seedling establishment. Regeneration post fire is thus achieved by the shedding of those seeds produced in the three years before fire. Ashton (1976) describes the development of even aged stands of mountain ash following 'severe' fire and suggests that '*The great forests at the time of discovery were apparently also of this type*'.

The Black Friday fires of 13 January 1939 burnt between 1.5 and 2 million ha, including extensive areas of mature mountain ash, estimated to have been 200 – 250 years old (Adams and Attiwill 2011). Given the requirement for widespread high-intensity fires in order to facilitate seed shedding, germination and establishment, this implies a major fire in the early 1700s (Adams and Attiwill 2011) which would appear to be contrary to Gammage's expectation. The large areas of *E. regnans* burnt in 1939 would already have been well established in the early nineteenth century. While Gammage (2011c) specifically allows for a 'not burning' option in the Aboriginal fire regime, to have left very large areas of highly inflammable forests unburnt for many decades, thus ensuring that when fire ultimately and inevitably occurred it would be both extensive and very high intensity, would appear to be incompatible with the fine scale patchy landscape that Gammage envisages. Lindenmayer *et al.* (2015) strongly suggest that Gammage's (2011c) model could not have applied to mountain ash forests. I would suggest that this could also apply to other tall wet eucalypt communities elsewhere in Australia which have similar regeneration characteristics.

Whether there was an oral account of the early 1700s fire (or other earlier high intensity fires in tall wet sclerophyll forest) passed down through generations of Aborigines does not seem to have been recorded, but examination of the traditional stories may be informative.

Since the classic studies of mountain ash forest by Ashton, Lindenmayer *et al.* (2011) suggest that the forests have undergone a regime shift resulting in them now being a 'landscape trap' as a *consequence of the interacting effects of fire and logging whereby a positive feedback loop between five frequency/severity and reduction in forest age at the stand and landscape levels leading to an increase risk for dense young regenerating stands repeatedly re-burning before they reach a more mature state.* Such a change results in very extensive and irreversible changes to the ecosystem. Perry *et al.* (2014) considers a similar landscape trap may have developed in New Zealand forests. It would appear that if alteration to the fire regime of mountain ash forest was wrought by Aborigines, the changes were insufficient to alter the nature of the ecosystem.

The ignorant colonists

Implicit in Gammage's (2011c) argument is that the breakdown of Aboriginal fire management after 1788 could be attributed to the failure of the colonists to appreciate the ecological role of fire – an assumption based on the supposed absence of the use of fire in the United Kingdom. If Australia had been colonised not by the British, but by the French (as it so nearly was) then the experience of fire in Mediterranean shrublands might have led to very different understandings of fire in the new land.

The idea that the colonists would have been unfamiliar with fire would seem to be supported by the memorable statement in Rackham (2006) *English native woods burn like wet asbestos* and *lack of fire as a significant factor in English woodland is the legacy of past management resulting in an unnaturally tidy wood lacking fallen branches. It is due to the anti-fire adaptation of native trees. Most have a leaf litter which compacts into a soggy mess. Fallen branches quickly rot: combustible deadwood never accumulates to provide fuel. This leaves only trunks, especially oak that are too big to burn on their own.*

Rackham (2006), however, was, in this quote, discussing mixed deciduous woodland in lowland England. He points out there are other vegetation types in which fire does occur, and in which there is a long history of fire being used in management.

In Scotland there is a different story. Scots pine *Pinus sylvestris* is, like other pines, fire adapted in that it has flammable resins and the cones are serotinous, shedding seed after fire. The fire cycle, Rackham suggests, needs to be not much less than 100 years. Although the major reduction in pines in Scotland took place some thousands of years ago, there were some pinewoods still present in 1788. It is possible that some of the Scots amongst the earliest European colonists in Australia would have known that pine woods burn. The Swede, Daniel Solander, who accompanied Joseph Banks in 1770, would have been familiar with the role of fire in pine forests in his own country. In south-west Ireland, a rare small tree today is *Arbutus unedo*, the strawberry tree, a Mediterranean species at the northern limit of its range. Evidence suggests that in historic times it was more widespread in Ireland. Around the Mediterranean it is a component of tall highly flammable shrubland, maquis. Rackham (2006) speculates that lack of fire in recent times may be a factor behind its decline in Ireland.

Pyne (1998), in his fire history of Australia, has a lengthy section entitled 'Homefires: a fire history of Britain' which commences '*Probably no fire practice in Australia – or throughout all of Gondwana – lacked an antecedent in Britain*'. Pyne has written very extensively on fire history. Gammage (2011c) does cite Pyne (1998), but reading Gammage and comparing it to the

Pyne corpus of work I found myself wondering whether, shorn of its illustrations, Gammage added anything substantial the ideas already discussed by Pyne.

Three types of British vegetation in particular were subjected to management by fire – heathland (both lowland and upland) reed beds, and coarse grassland (highly fertile species rich hay meadows were not managed by burning, but coarse grasses and less fertile sites were burnt to promote green pick for grazing).

Heathlands in northern Europe have a long history of being burnt deliberately by humans. Heathlands in this context are low shrublands, dominated by fine leaved members of the Ericaceae (*Calluna vulgaris* and *Erica* spp.) – unlike what is referred to as heath in Australia where there may be very high species richness in the shrub layer (Adam *et al.* 1989). Burning removes dead wood and moribund plants and promotes new growth and regeneration of greater nutritional value for grazing. Originally the grazing would have been by livestock, but in Britain, the development of large sporting estates in the uplands from the mid-19th century meant burning of heather was primarily for the benefit of grouse. Burning is conducted in rotation, on small patches – images of burnt heather moorland (for example on the cover of the *Supplement to the Muirburn Code. A guide to best practice*. Scottish Government 2011b) show patterns not dissimilar to Gammage's templates.

Burning is subject to legal restrictions – regulations of muirburn in Scotland can be found as far back as the 14th century, and the practice is even older. Today, burning in Scotland is governed by the *Muirburn Code* and the *Supplement to the Muirburn Code. Guide to best practice*. There are separate equivalent documents in England and Wales, and Northern Ireland (see Kirkpatrick 2013). In England, Wales and Scotland the legislation underlying governance of burning is the *Hill Farming Act* 1946 as amended by later legislation particular to the individual jurisdictions, and reflecting both United Kingdom and European conservation legislation. The various codes specify seasons (which may vary with altitude) in which burning is permitted, control and management of burns as well as specifying sensitive habitats which must be protected.

To the general public it might be surprising that the codes apply to reed swamps, reflecting general belief that wetlands do not burn. However, several wetland types are highly flammable, none more so than *Phragmites australis* (common reed) beds. These can accumulate large amounts of standing dead material, and even when the base of the stems are in water, beds can burn fiercely and the fire front move rapidly. (One of the most frightening experiences of my life was standing in knee deep water amidst a burning reed swamp.) Reed beds are a major fire hazard in urban and rural areas (in suburban Sydney, residents close to the Rockdale wetlands corridor regularly express concern about the dangers arising from their proximity to a dense reed bed). However, there is a long history of use fire to manage (for harvesting of thatching material) or control (where *Phragmites* is invasive) in various parts of the world. The response of *Phragmites* to burning may depend on the time of year. Gammage (2011c) contrasts different burning practices by Aborigines in different river systems, as described in early explorers records, and I would expect that prior to 1788 reeds swamps would have frequently burned, either through human intervention or following natural ignition. Colloff (2014) examines the historical records of fires on the floodplains of inland rivers. While there is evidence of burning, interpreted by the original observers as Aboriginal burning of reed swamps, the purpose of such fires is not clear. Overall, Colloff (2014) finds relatively few records of burning on floodplains.

Phragmites is a grass, and its ability to respond to fire reflects this. Grasses are supremely well adapted to tolerate loss of biomass, be it due to grazing, mowing or fire – the structure of the plants and location of their meristems promote survival and recovery. Management of grassland so as to maximise their utility for humans has had a long history around the globe, including in northern Europe. Gammage (2011c) has many quotations from the writings of early settlers which he interprets as suggesting early settlers attempted to mimic Aboriginal burning practices – I suggest that it is equally, if not more, likely that the settlers were attempting to manage grasses as they would have done for generations on poor quality land in Britain, albeit with the possibility of 'tweaking' details following observation of Aboriginal practices.

As well as use of fire being of widespread in Britain, the British had long experience with North America, South Africa and India, all places where the indigenous inhabitants made use of fire for various purposes.

There are other lines of evidence beginning to be explored which suggest fire may have played a greater role in the development of north temperate vegetation than has previously been credited.

In northern Europe the extent and frequency of fires is likely to have changed over time. *Pinus sylvestris* (Scots pine) was widespread in the early postglacial and, given the relationship between reproduction and fire in the species, its survival at any one site for more than one generation indicates the likely occurrence of fire. However, there is ample evidence of fire, in the form of charcoal, after the decline of pine and the development of other vegetation types. Ignition by humans is frequently invoked as the cause of fire and, until recently, little weight has been given to natural causes of fire in the temperate deciduous forest zone.

Recent studies from the New Forest in southern England (Grant *et al.* 2014) cast doubt on the anthropogenic fire model and suggest a greater consideration of natural

causes is warranted. These findings also suggest that Gammage's assumption that much of the British flora is fire intolerant (and thus a stark contrast to Australia) is too broad a generalisation. Grant *et al.* (2014) report that over a 5000 year interval (from early to mid-Holocene) the incidence of burning is related to climatic conditions and vegetation composition and is highest during periods of warmer and drier climate. The evidence suggests that the climatic signal in the fire record is strong even though there were human influences.

In later periods, with greater clearing of the landscape I would expect that opportunities for extensive natural fires to have declined, but the inherent flammability of some north European vegetation (excluding species such as oak) has been demonstrated by the extent of grass and heath fires (ignited by humans) which have been a feature of dry spring conditions in recent years.

The parkland

A term in many of the accounts cited by Gammage is 'park' – the landscapes were like a 'gentleman's park'. This notion is taken up by Gammage in the reference to an 'estate' in his title. The estates of landed gentry in Britain included their grand houses, the dwellings of their tenants and servants, farm buildings and farmland and their parkland. Gammage (2011c) stated that the use of 'park' by Europeans to describe parts of the Australian landscape was *striking, for three reasons. First, 'park' was not a word Europeans elsewhere associated with nature in 1788. Until 'national park' was coined in the United States much later, a park was man-made. Second, 'park' did not mean a public park as today, for few existed in Europe in 1788. It meant parks of the gentry, tastefully arranged private estates by people comfortably untroubled by a need to subsist. Third, few today see parks in Australia's natural landscape*. (Similar sentiments appear in Gammage (2005), although the second of the three reasons is absent in the earlier paper.)

The third of these reasons is questionable. Being familiar with the appearance of some of the great English estates, I have referred to the occurrence in some estuarine sites of *Avicennia marina*, not as a dense monoculture, but as well separated trees in saltmarsh, as looking like parkland – some Australian savannas also remind me of parks. I am sure I am not alone, but this is not my main reason for taking issue with Gammage's claim. Rather it is that, well over a century earlier, the analogy with English parkland had been drawn in relation to areas in North America.

In the influential work edited by Thomas (1955), on the effects of humans on the landscape, Sauer wrote of the deciduous forests in North America *our eastern woodlands, at the time of white settlement, seem largely to have been in process of change to park lands*. Williams (1998, 2003) discusses the eastern American forests at the time of European settlement, pointing out that the impact of the Indians on the forest had not been admitted by historians and had been ignored by ecologists. The Indians made extensive use of fire, and also cultivated corn and other crops. Williams (1998) quotes from various settlers, writing in the 17th century, about the open park like nature of the forests in which it was possible to ride at a gallop, or even drive a horse and carriage, language identical to that used by early settlers in Australia. Williams suggests *this type of vegetational landscape was noticed particular by the British travellers and settlers, not only because of its utility and the ease of movement in it but also because of its aesthetic qualities. Such a landscape was comforting and pleasing, as it suggested domestication and a touch of art and intimacy, and this was a preference deeply rooted in British landscape aesthetics, the very antithesis of American native landscape taste with its stress upon the wild and the absence of artificiality.*

The appearance of parks in the Australian bush was thus not something which would have been without precedence to English eyes, indeed it could be suggested that use of 'park land' had become a trope The question is how familiar were some of the early administrators in New South Wales with these earlier accounts from North America? This is a question for others, particularly historians, to address. Had this knowledge sunk into the background, or was it still known by reading the accounts, or by the continued experience, of settlers in America?

In England a park was specifically a place where deer were managed. Rackham (1989) finds the first record of park in late Anglo-Saxon times just prior to the Norman invasion. The number of deer parks increased greatly following the Norman Conquest.

Gammage (2011c) includes on his introductory pages one of the best known of the statements about the appearance of the inland when first seen by the Europeans – that of the surveyor Sir Thomas Mitchell's 1847: *fire, grass, kangaroos and human inhabitants, seem all dependent on each other for existence in Australia: for any one of these being wanting, the others could no longer continue. Fire is necessary to burn the grass, and form these open forests. But for this simple process the Australian woods and probably continued as thick a jungle as those of the New Zealand or America.*

Was Mitchell's understanding of the 'thick jungles of America' shared by colonists in general? It is interesting that Mitchell had adopted the term jungle - derived from India.) Why was apparently once widespread knowledge lost? In the case of New Zealand, what information was in circulation in Australia in 1847? While there was still extensive thick forest in New Zealand, there had been large scale clearing particularly in the east since the arrival of the Maori (a very much more recent event than the arrival of humans in Australia). Use of fire by the Maoris had been important in both achieving clearing of the forest and in maintenance of the open landscapes subsequently (Perry *et al.* 2014).

Grasses

The promotion of growth of grasses following fire is an essential component of Gammage's model, as this attracted kangaroos and other grazers, which could be hunted. Gammage is of the view that Australian grasses are different from grasses elsewhere. In an interview on the ABC Radio National programme *Bush Telegraph* in October 2011, at the time Gammage (2011c) was launched, he suggested that Australian grasses differed from English grasses in being perennial as distinct from annual, and that the regrowth of green pick after fire was a phenomenon of perennial grasses. In Gammage (2011c) it is stated (page 32) *Most introduced grasses are winter or spring flourishing annuals; most natives are summer flourishing perennials*.

While there are annual grasses in Britain, British pastures and semi-natural grasslands are comprised of perennial species (Cope and Gray 2009). Some of the annual species have been introduced into Australia, and in some habitats, such as upper saltmarsh fringes in southern Australia they may be locally common. However, it is introduced perennial pasture grasses which have had greater environmental impact. Invasion by perennial pasture grasses has been recognised as a key threatening process under the *Threatened Species Conservation Act* in NSW. Some introduced perennial grasses alter fuel characteristics and fire regimes of the invaded communities, for example buffel grass *Cenchrus ciliaris* (Miller *et al.* 2010), and gamba grass *Andropogon guyanensis* (Rossiter *et al.* 2003). Introduced annual species can also change fire characteristics, the most notable example is cheat grass (*Bromus tectorum*) in western USA (Cope and Gray 2009).

There are some distinctively Australian grasses – for example *Trioidia* and *Plectrachne* – the spinifex of the inland, which are grasses with the form of shrubs and which are highly inflammable. (The spinifex of the inland is not to be confused with the coastal *Spinifex*, the native dune former, but with a very different growth form from the dense tussocks of *Ammophila*, deliberately introduced from the northern hemisphere for sand dune rehabilitation, which has changed the geomorphology of dune systems).

The major crop species of grass introduced to Australia are annuals, and extensive paddocks of wheat represent a habitat type without pre-1788 equivalents. At the time of European settlement, post-harvest stubble burning was not a widespread practice. Stubble burning in the UK became a common practice after the Second World War but problems, particularly from smoke, raised public concern leading to introduction of regulations which have led to its cessation. Management of crop residues by burning has a long history in many parts of the world. It has advantages in controlling pests, pathogens and weed, and in providing an ash bed effect for the next crop. However, there are potentially issues of pollution from smoke (which can, in addition, be hazardous if it leads to low visibility on roads), facilitation of nutrient loss and damage from out-of-control fires. As the size of arable fields increased and the population of farmers and farmworkers declined, these problems increased. In England and Wales, the use of fire to manage crop residues has been very heavily curtailed since 1993 when the *Crop Residues (Burning) Regulations* 1993 were made. For all effective purposes, broad acre stubble burning has been banned in England and Wales since that time (stubble burning is not so restricted in Scotland but the acreage of cereals is smaller). Although not well documented, it would not be surprising if post-harvest burning was practised, if only on a relatively limited scale, from early in the European colonisation in Australia.

The answer lies in the soil

Gammage (2011c) suggests that under Aboriginal management most soils were soft and spongy but since 1788 these properties have been lost. It is true that cropping and the introduction of cloven hooved animals have had major impacts on soils, but Smith (2014) argues that a sweeping generalisation about all soils is not supportable, and indeed that frequent burning is likely to have reduced organic matter in the soil, so that less burning would lead to higher accumulation of soil carbon, so that the structure of the soil would have become spongier. Smith (2014) also suggests that Gammage's assertion that 'typically grass grew on good soil, trees on poor' is again an oversimplification, with obvious exceptions. Smith (2014) appears to be the first to raise these issues in this particular debate, and they are matters which require further consideration. In supporting Smith (2014) on this I am not endorsing the major point of his article which is entitled *In praise of exotic species*. There is currently debate about the most appropriate approach to the management of introduced species, with strongly divergent views (see, for example Thompson 2014) – the issues are complex and unlikely to be easily resolved- but some ideas of the emerging commentary about introductions possibly come into the 'dangerous' category.

Other evidence

What the plants tell us

Gammage (2011c) suggests that evidence from plants provides important information about fire and fire regimes, but does not develop this theme.

There are at least two types of evidence plants could provide:

- information about likely long-term fire frequencies on the basis of post-fire reproductive characteristics of species,
- information about particular fire events recorded as scars in still living or newly dead plants.

Plants differ in their response to fire intensity and frequency. Gill (1981a, b) drew important distinctions between species in which individuals were killed by fire which regenerated from seed. The seed bank could be either in the soil, or on the plant and shed after fire. Species which regenerated by vegetative regrowth either, depending on the species, did so from aboveground stems or from below ground woody structures. For plants which recovered post fire from seed, an important parameter is the length of the juvenile phase – how long it takes from germination until an individual makes its first contribution to the seed bank. If the recurrence interval of fires is less than the length of the juvenile phase then local extinction is likely (although given that no fire is homogeneous there may be micro refuges which might permit survival of a small number of individuals). Juvenile phases, which have been reported range up to more than 10 years, are not known for many species, nor is there much information about variation on the length of the juvenile phase within populations of single species.

If, as claimed by Gammage (2011c page 168) *Most of Australia was burnt about every 1 – 5 years depending on local conditions and purposes* then it is likely that species with long juvenile phases would be eliminated by such a regime. However, exactly what constitutes 'most' is not specified nor are the local conditions which might lead to modification of the nature of the applied fire regime. Although Gammage (2011c) does allow that some communities would not have been burnt at all he does not specify which, nor their extent. Rainforest is likely to have been one, but overall during the Holocene the extent of rainforest at the national scale would have been small, although in some cases proportionately larger at the regional scale. Interestingly a number of rainforest species can recover vegetatively from at least a single fire (Adam and Williams 2001) - repeated fires at 1-5 - year intervals might not be survivable. Fine scale mapping of the distribution of species with different lengths of juvenile phase might be of interest. If there was long-term small patch burning at short intervals, with the patches being maintained over successive fire cycles, then localised absences of long juvenile phase species could possibly define the patches and indicate the extent to which landscape scale burning was conducted.

Fire scars could potentially reveal the fire history experienced by individual plants.

Grass trees (*Xanthorrhea* species– neither grass nor trees) are long-lived, with some individuals dating from prior to the European period. Dark marks in the remnant leaf bases on stems have been suggested to have been produced in previous fires. There was considerable interest in recording the frequency of these marks over time and it was suggested that they provided a means of identifying past fires. Early studies in south-west Western Australia suggested that fire intervals of 2-4 years were widespread in the early colonial period and the inference was drawn that this reflected the Aboriginal burning cycle. However, later studies have indicated anomalies (Enright *et al.* 2005, Miller *et al.* 2007). This suggestion of unreliability of the grass tree record has been fiercely attacked by one of the early workers on the topic (see Ward 2008). The points of contention are various but are based largely on the validity of statistical approaches to comparing data from satellite images and the fire marks. My reading of the various positions suggests that there is merit in pursuing research on the topic but that at present it would be inappropriate to put too much faith in the currently available data. (If the fire interval as recorded by grass trees was indeed 2-4 years then the community , including other species, must have been affected by fire at the same frequency. Is the whole flora in the community equally adapted to such a short interval?)

Fire scars on trees are accepted as a valid source of data on fire intervals, but data from Australia are limited. The length of any record will depend on the species of tree, but could be several hundred years, extending in Australia to before the documentary records, but not as far as some forms of palaeoecological record. Fire scar data are likely to provide a fine scale temporal record. In terms of addressing questions about Aboriginal fire regimes an issue is whether or not the high frequency, low intensity patterns postulated by Gammage would have sufficient intensity as to leave scars. A study by von Platen *et al.* (2011) in dry forest in eastern Tasmania suggested that low intensity fires were detected, and importantly that there was no difference in the record of rough barked and smooth barked trees. The data indicated that between 1740 and 1819 the decadal fire frequency averaged 0.7. In the years following displacement of the Aborigines mean decadal fire frequency was very low at 0.4 between 1820 -1849. Subsequently the frequency increased greatly, between 1910 and 1981 varying between 1.3 and 1.7. Extensive fires occurred in dry years, but variation in rainfall did not explain the changes in frequency. Von Platen *et al.*(2011) point out that the pattern of variation during the Aboriginal – European transition does not correspond to that in the very few records for the mainland.

Within the east Tasmanian study site von Platen *et al.* (2011) point out that while use of decadal average data reveals an overall pattern, there is a great deal of temporal and spatial variation, and that this variation is important for the long term maintenance of biodiversity. A wide variety of studies using a range of approaches in a wide range of ecosystems reaches similar conclusions- arguing against the very long term temporal uniformity implied by Gammage's mosaic burning model.

There are insufficient studies to draw any nationwide conclusions about a record from fire scars- but the fact that the few reports have differing patterns suggest that there is not a single universal story to be told.

Palaeoecology

Palaeoecology, globally, provides the majority of data on past environments beyond the historical period.

Curiously Gammage provides little discussion of palaeoecology, not even to reject its findings. In Australia, where the historic record is so short, this is unfortunate. Gammage uses the short historic record as the basis for extrapolating back 50,000 years. Palaeoecology can directly explore this longer period, and in the absence of other sources is the only primary record.

Palaeoecology can address many issues that are of particular relevance – the first is by the study of changes during the transition from Aboriginal Australia to the colonised landscape. There are unlikely to be many sites providing intact records over the relevant period which have sufficiently fine scale temporal resolution, but the information they yield can help address the question whether fire frequency changed as Europeans took over the land. Secondly there are much longer term studies over the time period since the arrival of humans on the continent, currently estimated to be about 50,000 years ago.

The most frequent sources of data are fossil pollen and charcoal. In the Australian context pollen has a few limitations – a number of taxa which are important in Australian vegetation cannot easily be discriminated on the basis of pollen. Particularly unfortunate is that while *Eucalyptus* pollen is distinctive, there is little discrimination below generic level. Preservation of pollen requires particular conditions of permanent waterlogging which are rare in Australia. Much of the continent does not provide suitable conditions so that the record is geographically biased with few sites throughout most of the inland and most sites in the east, particularly in the south-east. (Nevertheless there is a similar geographic bias in the historic record considered by Gammage (2011c).

For the colonisation period an important site is Jibbon Lagoon in Royal National Park, studied by Mooney *et al.* (2001). The data do not confirm expectations of a decline in fire frequency post 1788. The pre-European period is characterised by low concentrations of charcoal with only one apparently large fire event in 1600 years (Mooney *et al.* 2001). In the European period, up to the early 20th century, there is very little charcoal influx into the site, which Mooney *et al.* (2001) suggests indicates absence of fire. Since the 1930s the charcoal record indicates a relatively high fire frequency with two large fire event in the 1940s.

Jibbon Lagoon is close to the ocean coast and Port Hacking, which would have provided abundant seafood resources to the local human population since sea level reached approximately its current position 6000 years ago. Nevertheless, whatever the size of the original population present before 1788 it does not appear to have regularly burnt the bush. Mooney *et al.* (2001) concluded that it would be unwise to base fire management regimes on regular low intensity fires, as advocated by Flannery (1994).

There have been several recent reviews of fire regimes in Australia over the late Quaternary. Mooney *et al.* (2011) examined charcoal data from 223 sites – predominantly from the East of Australia, focusing on the last 70,000 years. They found that variation in biomass burning was correlated with climatic change. There was no change around 50,000 years ago when humans are thought to have reached the continent. The place of arrival is uncertain, but if it were the north-west (as is most frequently suggested) then there are a few sites in the database from that region. Nevertheless subsequently there was no evidence of a relationship between burning and the increase of human activity shown by the archaeological record. Williams *et al.* (2015) explored in more detail the fire record and measures of Aboriginal population over the last 20,000 years. The correlation between the two was generally weak and the authors suggest that the major driver of change in fire activity was climate, while not discounting the possibility of local manipulation of fire regimes. (Over a shorter time period this is a similar conclusion to that of Grant *et al.* 2014). Williams *et al.* (2015) found no evidence to suggest systematic fire management by the human population.

This is not to argue that the human colonisation of Australia did not have widespread profound impacts on the environment, but at least in relation to fire the stronger driver of change was climate.

The practice of ecological history

One of the most interesting and revealing sections of Gammage's (2011c) book is Appendix 1, entitled Science, History and Landscape. Given its position outside the main text, I suspect that it might be ignored by some (perhaps many) readers, even though it is, in many ways, a key to interpreting the whole book, as it explains the conceptual lens through which the author views environmental history.

Gammage is critical of scientists in general (with a few exceptions) but reserves particular scorn for Bowman and Fensham. Bowman is one of Australia's most prolific ecologists, who has conducted and published on aspects of fire ecology in a diversity of ecosystems from the tropical north to Tasmania. In addition to ecological research, he has conducted original ethnographic research with Aboriginal communities in the Northern Territory (Bowman *et al.* 2001). Bowman is prepared to act as agent provocateur, putting challenging arguments in the literature to generate discussion, but he has published a very highly regarded major collection of research outputs.

Fensham has also published over a wide range of ecological topics, but where Gammage takes issue with him is his use of explorers' records to interpret and reconstruct past vegetation.

Neither Bowman nor Fensham have denied that Aborigines used fire, and that Aboriginal practices in particular locations profoundly influenced vegetation.

Gammage is concerned by the multiple explanations that ecologists advance to explain the distribution of species and communities. He acknowledges that factors such as geology, soils, drainage etc. are correlated with changes in the distribution of species and the boundaries of communities. However, he seeks an overarching general explanation of these phenomena, which to him is best provided by his model of the use of fire by Aborigines.

Ecology, throughout its existence as a discipline, has sought general rules– with, to date, little success. This has been the cause of criticism over an extended period by scientists in other disciplines, and has also been the subject of critical comment by ecologists (for example Peters by 1991). I have no doubt that ecologists will continue to propose new unifying laws, and maybe, one day, there will be a breakthrough. In the meantime we can continue to identify factors which individually or in conjunction with other factors can explain distributions and abundance of individual species and communities. In this mix in Australia, historical factors, including involvement of Aborigines, will be relevant in some, perhaps many, instances.

Gammage seems to wish for a privileged position for the approach of the humanities in explicating environmental history. I would be disappointed if the field became bogged down in a demarcation dispute between disciplines seeking to preserve turf. Instead I would advocate adoption of the approach advanced by Smout (2009):

"Crucial to the advancement of environmental history in many of its aspects, is engagement and collaboration with science. The Americans, and to a much smaller degree the British, distinguish between ecological history (largely pursued by scientists) and environmental history (pursued by humanists). This unhelpfully encourages each to stay either side of the science/arts divide instead of collaborating to use one another's methodologies and sources. For instance, palynology, the study of fossil pollens, will tell you things about the history of a wood no document can ever reveal, like its changing species composition or ancient episodes of clear-fell. The documents can demonstrate what the palynologist can only speculate about: why, in eighteenth-century Argyll, oak pollen declines – the oak did not decline but was being coppiced on a rotation too short to allow for flowering. There are not many polymaths who can take both science and history on board in their own skill set (there are some, like Oliver Rackham). But it is not intellectually difficult to set up collaboration between scientists and historians on a research topic, though it may be institutionally difficult. For all the good words about encouraging interdisciplinary search, when push comes to shove, schools, faculties and universities are often unwilling to cross the zealously defended boundaries, or research councils to award money for work that lies partly out with a narrow remit. If they do, the institutions may next fall out quarrelling over the distribution of the money. The social anthropology of academe is troublesome, but such difficulties should not deter us from trying."

These observations about multidisciplinary studies, while clearly applicable to ecological history, have much broader resonance. Politicians and policymakers frequently proclaim the major breakthroughs in the future will come from multidisciplinary collaborations. If this is the case then the rhetoric does not match the reality. It is difficult for multidisciplinary proposals to gain support, particularly when, as in Australia the overall success rate for funding is so low, and assessors are frequently in one particular discipline camp.

Within the field of ecological history (and it is not clear that this is where Gammage would place himself) it is clearly inappropriate for any individual discipline to claim superiority - we need genuine collaboration. The skills necessary for the study of primary historical documentation are not those that most scientists have, equally historians are unlikely to have practical skills in fields such as palynology. What is required is that practitioners of one discipline recognise the potential contribution that others may play. In some cases that may require that researchers in one discipline may present challenges with those in another may not previously have considered. The consequence may lead to significant advances at the cross disciplinary interface, but also to new research directions in individual disciplines. I am not suggesting that all writings in ecological history should be multi–authored, but that anyone setting out single handed to tackle an aspect of ecological history will need to have a collegiate approach to consulting and acknowledging others.

Any worker wishing to engage in environmental history would be advised to take heed of Rackham's (1989) observation: "Why write yet another book on Forests? There are, for a start, two versions of Forest history: One cannot be true, the other may be. Forests are one of the most prolific fields of pseudo-history – a consistent, logical, accepted corpus of statements, copied from writer to writer down the centuries. We still read, for example, that Forests necessarily have to do with trees; that mediaeval England was very wooded: that the king's hunting was protected by savage laws and extreme punishments; that trees disappeared because people cut them to build ships; that trees can only be regained by planting them; and that the Forestry Commission is heir to the ancient Forest administration. The story reads well and makes excellent sense, but has no connection with the real world; it cannot be sustained on the records of any actual forest or wood."

Myths abound in the original records of many ecosystems. Rackham was writing in the context of Britain, but even though documentation and literature in Australia is much more limited than that in Europe, I suspect that 200 years has been long enough for myths to have become firmly established in 'general knowledge'. There are many views of an 'idyllic' rural life held by urban dwellers longing for a tree-change, while rural dwellers may hold dogmatic views about an imagined past (see Watson 2014).

A specific test

Kimber and Friedel (2015) extract from Gammage (2011c) a series of statements which they treat not as statements of fact (which is how Gammage presents them) but rather as a series of hypotheses which they then proceed to test in the context of the Lake Eyre Basin.

Gammage (2011c) makes five claims for fire pre -1788 (page 185). Gammage makes frequent reference to 1788 fire – this is a shorthand way of referring to fire regimes pre- and post-European colonisation. Sydney was colonised in 1788, but the time of first contact varied across the continent, extending over many decades. The fire regime of the time of contact is what is referred to as the 1788 fire regardless of whether it was 1830 or even later. The five claims are: it was planned; it was precise; it could be repeated, hence predicted; it was organised locally; and it was universal – like songlines it united Australia. (The concept of songlines is itself a matter of debate.)

It would be accepted generally that Aborigines did plan fires. The unresolved question is whether this applied to all fires (some could have been natural lightning fires, in other cases fire might have been accidental), and if planned whether things always went to plan.

The claim that the fire was precise depends on what was planned and whether the plan was achieved. If it was planned then the plan could be repeated – if it was precisely repeated then the template would become etched into the landscape, and the fire regime would be analogous to an agricultural rotation, with the patches being equivalent to fields.

All the observations of early colonists would support that fires were organised locally. Indeed it is difficult to think of any society, at least until the late 20th century, where fire management, even when management was centrally mandated, was not primarily a locally-based activity.

Universality is perhaps the major original claim proposed by Gammage. It can be agreed that Aborigines across the continent used fire from a variety of purposes, it could also be agreed that one of the uses may have been what we would now term land management. However, if universality requires that there be one Law and that the patch mosaic model applied across space and time, a considerable leap of faith is required.

Kimber and Friedel (2015) examine the records of explorers, early settlers and anthropologist from a large part of the Lake Eyre Basin. The author both possess many years of field experience across this region.

Gammage (2011c) views examination of historical records as the province of historians, and is critical, in his Appendix 1, of Fensham's use of explorers' records. He would probably be equally critical of Kimber and Friedel, but to understand the historical record requires interpretation and knowledge of the country concerned, and I consider that Kimber and Friedel are well qualified to undertake the task. Their discussion recognises the problem that observation of distant smoke does not provide information about the purpose and source of fire, but they also argue that it is important to note the absence of records of smoke and fire, and not assume that absence reflects failure to observe and so extrapolate from adjacent areas to fill the blanks on the map.

They recognize Aboriginal knowledge of even the smallest features of country and note that fire management to protect local features (even some individual trees) occurred. They suggest that there were some limited areas of mosaic burning, but that across most of the region most of the fire records were too far apart to support a mosaic burning model.

The Lake Eyre Basin is not the whole of Australia, but is a significant portion of it. If only small selected parts were subject to mosaic burning then the universality of Gammage's model is called into question. Kimber and Friedel (2015) conclude that 'assuming that mosaic burning is universally applicable may be unwise.'

Discussion

Gammage is a handsome production which contains much interesting material. However, as I hope I have demonstrated in the preceding discussion, I do not consider that it is the last word on the subject. It raises ideas which require much further investigation and this investigation needs to cover the whole continent and be collaboratively multidisciplinary. Covering the whole continent is difficult in that many sources of data are geographically and temporally limited.

Gammage assumes (or imposes on them) uniformity of behaviour in the Aboriginal population of Australia. Given the length of time Aborigines have been in Australia, the size of the continent and the existence of a very large number of language groups I find this unlikely. Internationally one of the components of sense of place is a sense of difference. Local communities develop strong identities and the spatial scale of variation can be surprisingly small. While there are obviously national characteristics that unify differences remain. Gammage argues for One Law, although also acknowledging that implementation of this law would reflect local

circumstances. It is not clear what is left after the local variation is removed other than some very broad, almost meaningless, generalisations about fire being used as a tool. Today, the Aboriginal community is, in relation to many issues, not homogeneous. In relation to environmental issues there can be strongly divergent views between different communities, as is seen between groups in North Queensland.

Gammage presents, in Hiscock's (2014) analysis, an Edenic picture of Aboriginal society.

This, it seems to me, involves a belief in the balance of nature – which in its simplest formulations has long been rejected by ecologists, and has undertones of Rousseau's noble savage. The analogy with a gentleman's estate to describe the appearance of the landscape would suggest to a class conscious European society a superiority to the Aborigines. It is not clear to how much of the continent was of parkland appearance - it is unlikely to have been the case for much of the semiarid and arid zones, even though these regions supported Aborigines who lived off the land. Importantly the recognition of parkland does not make Aborigines unique, similar analogies had been drawn elsewhere in the British colonies.

It is important to recognize the fallacies inherent in the concept of *Terra Nullius* – the Australian continent was successfully inhabited and its resources utilised for millennia prior to 1788, and customary practice operated within a framework of communal holding of land.

The Aboriginal occupation of Australia, for probably 50,000 years plus, is a remarkable achievement – is something to be greatly admired, but while recognising the uniqueness of Australia's biota and environment and the Aboriginal response to the conditions I think it important to recognise universal features of the human species. Use of fire (in a variety of ways and variety of purposes) is universal, as is a sense of place and knowledge of country (even if expressed in different terms). Western society has lost many of its connections with nature (Scruton 2012), but the longing for place in nature is still widely held.

It is a commonly held view that Aborigines were almost exclusively hunter-gatherers, this is another historic claim which may contain large elements of myth. Gammage draws attention to the Brewarrina fish traps as an example of skilled construction techniques. The promotion and cultivation of some plants by Aboriginal groups verges on agriculture. Pascoe (2014) goes further in presenting an argument that Aborigines were involved in a range of activities across the continent which would be difficult not to classify as agriculture. Pascoe shares with Gammage a suspicion of scientists, but I feel that the case that Aborigines were not just hunter-gatherers is convincing, although it raises many more questions which require further study.

There is a curious paradox in Gammage's (2011c) attack on scientists, particularly as a major bone of contention concerns the findings of scientists that prior to 1788 the fire record shows a stronger message of climate change than of human impact. This contention is also expressed by some of Gammage's strongest supporters such as Rothwell (2011) and Rowse (2013). Gammage (2011c) argues that Aborigines made Australia, and yet at the same time suggests that they were in balance with nature. If Aborigines did make Australia then it is hard to understand how this could have been achieved without considerable ecological and environmental change.

It is true that the impact of humans on the environment has been recognised since at least 1956 (Thomas 1956) and that the current state of the Earth is to a large extent determined by humans – to the extent that there is currently a move to formally recognise that we live in the Anthropocene. (There were many authors who documented particular human impacts long before 1956, but there was a prevailing sentiment that our efforts were puny compared with those of nature). There is little doubt that during the period of Aboriginal occupation, there were major environmental/ecological changes, such as the introduction of the dingo and, at least locally, burning. However, the evidence is clear that at the continental scale the major changes in the last 50,000 years have been largely due to climate (Mooney *et al* 2011, Williams *et al.* 2015). This possibly reflects the inherent harshness of much of the Australian environment so that the human population, already close to the limit, might have been particularly sensitive to climate change over wide areas.

The influence of climate is not only reflected in the palaeoecological record, but can also be seen if the genetic structure of living organisms. Sakaguchi *et al.* (2013) reported a study on *Callitris*, a widespread genus of fire sensitive conifers in Australia, and thus a group which might be anticipated to respond negatively to the sorts of fire regimes postulated by Gammage, and suggest that the impact of climate change on fire regimes overwhelmed any modifications to fire regimes by Aboriginal landscape burning and make a formal extinction, a finding that probably also applies to other fire-prone vegetation across Australia.

I agree with Gammage in his argument that there was no wilderness – if by this is meant that there are no areas on Earth (with the exception prior to the 20th century of Antarctica) unaffected by human activity. The modern concept of wilderness (as distinct from its biblical connotations) dates to the late 19th century in the United States of America. The concept of wilderness reflects an idealised view of the environment and writes First Nations and their role in environmental management out of history. It ignores the role of indigenous peoples, including, *inter alia* Aboriginal Australians and North American Indians over many centuries. All landscapes are cultural landscapes.

However, while this needs to be acknowledged and embraced, and be the subject of active education of the broader public, I can see value in conserving very large areas where there is minimal current human activity and which provide opportunities for conservation of large populations of many species and the continuation of ecological processes. If calling these areas wilderness secures their conservation then the outcome may justify the means. However, wilderness is also a state of mind, and, for some, even small patches of urban bush, because of the contrast between the bush and surrounding area, can create a sense of wilderness.

Is Gammage (2011c) dangerous? The fact that aspects of the book can be challenged does not make it dangerous – matters will be resolved through the normal academic processes, although this may take some years. However, what is dangerous is the use of the book to support particular approaches to fire management, and in particular the advocacy for high-frequency control burning, returning the country to the Aboriginal fire management regimes. This is dangerous for at least two reasons:

Firstly, the generality of Gammage's conclusions is not established; secondly, the environment has changed since 1788, and the current objectives for land management may differ from those of previous times. Even if Gammage's hypothesis is correct for Australia in 1788, what is appropriate in modified environments nearly 250 years later is a completely different question.

Reasons for not being convinced of Gammage's claim of a single estate have been discussed at length. His desire for one single 'answer' is reflected in his criticism of scientists and (to Gammage) our multifactorial solutions, a position strongly supported by Rothwell (2011) – a careful defence of the position of scientists is presented by Colloff (2014). In particular the advocacy of a single estate does not acknowledge biases inherent in information availability. Firstly the majority of explorers' and early settler' records are from the south east. Secondly in their movements about the landscape I would strongly expect that European travellers would have opted for easy access. The explorers reported clear understoreys precisely because they provided for easy travel, and these areas were also attractive, and were possibly created by, Aborigines, but this evidence does not say much about conditions away from the cleared areas – distant from the 'transport corridors' and in little visited areas the vegetation may have been very different, but we will need other forms of evidence to determine its nature.

The changes to the environment since 1788 are many, but include the dispossession of many Aboriginal communities from their land, with the abandonment of management practices, fragmentation of the landscape and the construction of towns and infra structure, increase in atmospheric carbon dioxide to levels higher than at any time during the proceeding Aboriginal sole occupancy, introduction of numerous plant and animal species (the response of Aboriginal people to introductions may be more accommodating than many Europeans- if they have uses they may be tolerated or even encouraged) with ecological consequences, vastly increased human population putting pressure on resources, and different objectives for the management of particular areas.

Bowman (1998) stressed that in this changed world, new management solutions may be required and that 'old' solutions may no longer be appropriate.

This is not to deny that where there has been greater continuity of Aboriginal involvement in land management- as is the case particularly in Northern Australia (that part of the continent in which currently a vocal lobby seeks intensified European development) then application of Aboriginal management may be desirable, although the environmental changes since first contact may necessitate evolution of modified practices (and although Gammage appears to suggest continuity of practice over millennia, the magnitude of 'natural' environmental change during that time would have required changes in practice - so I would expect continued evolution of approaches to occur).

I would suggest that among many possible lines of research, it would be useful to explore more fully the prior experience of early settlers with fire and its management. Amongst Scots at least, experience of muirburn may have led to an appreciation of Aboriginal fire use rather different from that assumed by Gammage. I would also suggest that a linguistic/anthropological investigation of vocabularies for vegetation types would provide information about the diversity of vegetation types in 1788, but also provide an indication of what types of vegetation might have been either protected from fire, or have been repeatedly burnt.

Rewilding

Another topic in which data from environmental history may be misused in policy debate is rewilding, currently strongly advocated for by an effective group of lobbyists.

Rewilding is a rather amorphous concept, which covers a number of different activities – the reintroduction of individual species into locations from where they are known or assumed to have become extinct, the re-establishment of processes that are assumed to have operated in the past, and, at the extreme end of the spectrum, the re-creation of totally extinct species. All of these give rise to a range of issues but I will briefly address the first two which are related in that introductions frequently have the intent of enhancing ecosystem processes, as for example in proposals to reintroduce top carnivores.

A particularly vigorous debate has been initiated by the work of Vera (2000) who questioned the previously prevailing wisdom about the structure and dynamics of

primeval forests in lowland Europe. Vera (2000) extends his discussion to North America, but his ideas had much more influence in Europe. Primeval is a loaded phrase if it is taken to imply lack of human influence, as even small number of humans could have had considerable impacts. The two competing hypotheses are the 'high forest' and the 'wood-pasture' proposed by Vera under which large herbivores maintained an open landscape with a mosaic of grassland, scrub and forest groves. Under Vera's model the herbivores controlled the structure of the landscape whereas the high forest model is essentially the obverse – forest structure determining herbivore populations. The wood–pasture model envisages that the European landscape in the early post glacial period had many attributes of parkland, albeit be it a parkland created by herbivores rather than humans.

Vera's hypothesis has created considerable interest amongst conservation agencies because, if correct and if the object of conservation is to maintain landscapes in an assumed natural state (an objective which is frequently taken for granted rather than being analysed and debated), then management should aim to replicate the wood-pasture pattern (see discussion in Birks 2005).

Examination of the palaeoecological records from across Europe by Mitchell (2005) found little evidence to support the wood-pasture hypothesis – which is not to deny that large herbivores occurred in the forests and had important ecological roles.

As part of the development of conservation management policies following publication of Vera's book there has been much greater use of grazing in management, not necessarily to create wood-pasture but in the management of a range of other habitats such as grassland and heathland. This has resulted in activities meeting two objectives – management of ecosystems and conservation of rare breeds of livestock (Small 2015). In the UK a number of non-indigenous breeds and species have been used in conservation management – notably Konik Polski ponies and the more exotic water buffalo which are now present in a number of UK reserves. Small (2015) finds use of exotics difficult to justify, but even when indigenous breeds are used, such as Hebridean sheep, they are in locations far removed from their historic place of origin so the distinction between exotic and indigenous is not in many instances absolute.

There are much promoted plans for the reintroduction of wolves and bears in many parts of Europe. There is often strong (and understandable) community concern, but while introductions of top carnivores have occurred in some countries, in others a range of legal restrictions prevent free range introductions. One of the most widely reintroduced species in Europe is the beaver – opposition in Scotland to introduction was led by angling interests (although their claims the beavers would eat fish reflected ignorance of beaver biology). However, beavers are literally ecosystem engineers and maintenance of rivers and channels could well be affected by them.

I would agree with Smout (2009) that reintroduction proposals are often not well thought through: "Importantly, proponents of rewilding always (and rather paradoxically) deny any intention to recreate a particular point of time. In this they differ from those who seek to restore a historic building, who either want to recreate its appearance at a particular point (say, on construction) or to 'conserve as found', a modern preference for retaining the patina and alterations up to the point of bringing the building into restoration management. Nature conservationists have two emphases in their response to the query about why they do not seek any point in time. Many say they are trying not to recreate a period anyway but to liberate a natural process: at Oostvaardersplassen[2], this process is naturalistic grazing, where ungulates impact on the landscape without human management or intervention. Others would say that you cannot exactly recreate a point in the past, partly because it is unknowable in sufficient detail but mainly because, with the best will in the world, many of the parameters are different now: the absence of wolves or the presence of non-native (alien) species, or simply a different climate where changes may or may not have anthropogenic causes. There is the further point that ecosystems, even those minimally disturbed by man, are never static. Clementsian notions of a climax, which, once achieved, was for ever stable, have been replaced by a picture informed by chaos theory, of ecosystems in constant change, one tree species randomly replacing another as dominant in the forest, pine or elm advancing or retreating as affected by climate for disease, disturbance the norm. Yet this does not prevent an obsession with the original-natural, taken in Europe to be the Mesolithic,in America the pre-Columbian or at least the time before white colonisation."

"However, we can lift the stick from the other end of time. What is the point of harking back to an original-natural that in Europe is unknowable, irrecoverable and 5000 years distant in time? It is simpler in America, where white colonisation is sometimes barely 150 years old, as on the buffalo commons. The European landscape around us is not Mesolithic and original-natural but modern and cultural. It is impoverished and becoming more so, but the biodiversity we value, and the Red Data Book species we especially treasure, are largely the product of the cultural landscapes that immediately predated this one."

I would question whether it is simpler in North America or Australia in that the pre-European landscape had been profoundly influence for thousands of years by the indigenous inhabitants of those continents.

"Some rewilders, particularly in Scotland, are much less interested than English Nature or than Vera in environmental history, ancient or modern. Once they have convinced themselves of an original-natural state, typically based on the popular myth of the Caledonian Forest, they carry on with recreating what it represents, irrespective

2 Oostvaardersplassen is a large experimental polder in the Netherlands, which is a major trial site for Vera's (2000) ideas.

of 5000 years of climate change and human activity, or its mark on the landscape, and certainly irrespective of research. This can lead voluntary bodies and individuals to attempt idiosyncratic landscape change. What they will end up with will not be natural, but cultural landscapes that memorialise early third millennium conservation theories. These will be interesting landscapes in themselves, but probably not what they were originally."

The re-introduction of species to areas from which they have become extinct raises many issues. The environment to which re-introduction is to occur will not be the same as that present prior to the local extinction. The very absence of the subject species will have had consequences of the ecosystem structure and composition, and these are likely to increase over time since the extinction. Human activity may have resulted in further fragmentation of the landscape such that the patches of available suitable habitat are now much smaller, climate change may have already created inappropriate conditions for the species - or be predicted to do so in the near future – so the potential future viability of the introduced population may be doubtful. The founding population may be small, with potential genetic consequences. We may have no knowledge about the genetics of the population that became extinct, so therefore no way of knowing whether the source population for reintroduction, which may be from a location far removed from the reintroduction site will be adapted to its new conditions. Many of these issues could be overcome, but they all need to be considered. When reintroducing species, a species is treated as a species, whereas all species can be viewed as ecosystems. If the reintroduced individuals have been required to spend time in quarantine and undergo veterinary treatment, they are unlikely to carry internal and ecto parasites.

Proponents of rewilding, such as Monbiot (2013) are critical of the restriction and bureaucratic red tape which prevents or slows the process. However, in the context of the wolf in Scotland, which is a particular focus for Monbiot, the areas in Northern Scotland where reintroduction is sought have had a long history of degradation, in particular by over grazing, by both sheep and deer. Preparatory works for reintroduction have involved extensive fencing – to retain wolves when introduced, but also serving to exclude herbivores. The recovery of vegetation in these exclusion areas (which are far larger that the exclusion plots which have been traditional studied by ecologists) have been considerable (Monbiot 2013). I would suggest (as has Smout 2009), that the conservation benefits of grazing exclusion are far more certain than those of rewilding.

Every proposal for rewilding needs to be considered on its merits, and there may be cases, particularly if the local extinction has been very recent, or the proposal represents the last chance for conserving a species, where reintroduction is desirable. Rewilding is likely to be expensive, and in many circumstances the outcomes will be uncertain. Could there be better ways of spending limited conservation funding?

I consider the 'rewilding movement 'dangerous because of the associated complexity, cost and uncertainty.' Some of the proposals are based on mythology rather than historical research. Nevertheless there are very high profile supporters (in the UK including Prince Charles) and opportunities for sponsorship. A particular danger is from the actions of enthusiasts who carry out 'do it yourself releases, outside any regulatory and approval frame works. I suspect that in many ways reintroduction in the name of conservation appeals to those who, in the days before it became politically incorrect, would have been advocates for acclimatisation.

We know everything, don't we?

Particular dangers to the reputation of individual scientists, and the credibility of science in general, are associated with surveys. Barnes and Williamson (2015) discuss this in relation to the inventory of ancient woodlands in the United Kingdom. Ancient woodlands are a category of woodland which has achieved high public profile during the last few decades. Development proposals likely to have impacts on ancient woodland are guaranteed to generate considerable opposition and, potentially, political embarrassment. In order to give certainty (a word much loved by planners and politicians), so that impacts could be avoided or minimised, the national inventory was commissioned. This was, as far as woodland was concerned, to be a modern day Domesday Book, absolutely the last word on the occurrence and distribution of ancient woodland. Determination that a particular wood is ancient requires considerable fieldwork and biological recording, recognition of archaeological features and documentary research. However, hope that the inventory would be the definitive word was not met. The inventory undoubtedly located many ancient woodlands but possibly created a false dichotomy between ancient and not ancient, so that woodlands with valuable conservation features, and possibly including some elements of ancientness, did not benefit from the protections that ancient woodland was intended to attract. Barnes and Williamson (2015) suggest that the inventory included examples of what a biologist might refer to as false positives and false negatives.

Ancient woodland is not synonymous with old-growth, but many of the concerns about the need to conserve ancient woodland are also relevant to conservation of old-growth, and the identification of old-growth stands is similarly contested.

There is probably no natural community on earth for which a complete inventory of biodiversity in all its components is available (and this will always be the case,

however many resources are invested in biodiversity survey). When it comes to a particular subset of biodiversity, threatened species, we also have imperfect knowledge. Many threatened species are rare (and indeed rarity might be one of the criteria determining threat status). Sampling to locate rare species is difficult – well-known localities can be resurveyed, but finding new localities often involves serendipity, but absence of evidence does not amount to evidence of absence. Surveys are only valid at the time they were conducted – the distribution of organisms changes over time and space. New surveys using new sampling designs or new technologies can completely change our understanding. Knowledge of the distribution and ecology of microbats for example was changed by the development of acoustic signal recognition methods.

Concentration on threatened species as the object of conservation policy can involve neglect of the 'ordinary' and perversely promote biodiversity decline. This is bad (and dangerous) policy if the overall objective is to meet obligations under the Biodiversity Convention – but not in itself bad science. However, to the extent that scientists were involved in policy development, they cannot be absolved from all blame. Barnes (2012) discussed the contradictions inherent in UK conservation policies, under which there have been some major successes in the recovery of are species, but continuing decline in biodiversity, and Australia is not immune from the same problems. In NSW biodiversity legislation in practice has given particular attention to threatened species and communities, while giving far less scrutiny to threats to landscape scale diversity and connectivity. Attention has also concentrated on the present and recent past, rather than keeping options open for the future. Decisions on whether or not particular areas are worthy of protection are frequently based on out of date (and probably incomplete) surveys.

All too often, survey results are taken as being applicable for all time – major planning decisions may be made on the basis of old surveys, or assumptions are made that no threatened species are present when there was only ever detailed survey of a few higher taxa. Surrogacy between different taxonomic groups is often assumed, but rarely tested. Local non-professional naturalists can often discover new and unexpected occurrences of species, and this new information can be used to cast doubt on the accuracy and reliability of previous surveys, whereas no survey remains valid beyond its original date. When approvals are given there is rarely an obligation to report subsequent discoveries. Objectors to development proposals are often critical of ecological studies advanced by developers, and cast doubt on the proponent's experts, where often the problems lie in the failure to adequately describe the issues and lack of resources to adequately capture spatial and temporal variability.

It seemed like a good idea at the time

History is replete with innovations embarked upon with the best of intentions but which proved to have undesirable, even dangerous, consequences. When applications for licensing of new chemical products or processes are made, in most cases we lack information and understanding of the biological consequences to make decisions. We also lack mechanisms to detect and take action when unexpected consequences occur. When appropriate information is lacking regulators rarely openly apply the precautionary principle.

A classic example of the well-meaning introduction of new chemicals into the environment which subsequently proved to be deleterious is provided by the American chemist Thomas Midgley– a figure who was very well respected in his time and lauded by his professional colleagues (McNeill 2000). Midgley was responsible for the development of chlorofluorocarbons (CFC) for refrigeration. It was decades before the hole in the ozone layer and the role of CFCs in its creation was discovered. With the benefit of hindsight we could argue that the potential risks of CFCs should have been investigated before they were released commercially. Once the adverse effects were discovered the international response was a model of effective multinational collaboration. Unfortunately the problem of increasing greenhouse gas concentrations in the atmosphere is a much more complicated one to solve, and progress to date has been negligible.

Midgley was also responsible for the development of lead compounds as anti-knocking agents in petrol. This increased the lead pollution load along roadways, and Australia was eventually one of the first countries to legislate the banning of addition of tetraethyl lead to petrol. Given a very long history of knowledge about the toxicity of lead to humans it is, with hindsight, astonishing that no one thought that deliberately releasing lead into the atmosphere might not be a good thing.

Large numbers of new compounds are released every year, not all of which are exposed to the same rigorous testing as pharmaceuticals (and even in that field some products reach the market before unexpected problems emerge).

My second innovation which had consequences which would not have been imagined when it was first introduced is the humble shipping container. Shipping containers were invented by an American, Malcolm Maclean, in 1956. Prior to this, loading and unloading ships was labour-intensive and time-consuming. Today, apart from bulk carriers of single commodities such as oil, grain, coal and iron ore, virtually all sea trade of goods is in containers. Ships can now be loaded and unloaded quickly – with turnaround times measured in

hours and days rather than the days and weeks of earlier times. After being taken off a ship, containers can be transferred to road or rail without the cargo itself being handled. The reduction in handling and the increased security of containers has resulted in massive reductions in shipping costs and facilitated enormous increase in global trade over the last few decades. However, there have also been substantial environmental and social costs. Existing ports which had evolved over centuries were unsuited to handling containers. There has been a global boom in the development of new ports which provide for the intermodal exchange of containers, provide extensive flat areas on which containers can be stacked during the loading and unloading processes and the transfer to road or rail. The construction of these new ports involved loss of substantial areas of intertidal and coastal land, and as ships became bigger and bigger, more dredging of estuaries was required. Despite increased recognition of the ecological importance of estuarine habitats and the introduction of laws and conventions to protect habitats of migratory birds, there are in most cases exemptions for national interest which have continued to permit expansion of ports even in environmentally sensitive areas.

The great increase in world trade facilitated by containerisation has also facilitated the spread of species – quarantine services can only inspect a tiny proportion of the containers transported around the world.

From a social perspective crews of ships no longer have long periods of downtime in ports, and the size of crews has declined. The old communities associated with docks and warehouses and their associated industries have been lost, and the loss of estuarine habitats is felt by birdwatchers and those who appreciate the vistas of sky, sea and birds.

Even if the disadvantages had been anticipated, I doubt that there would have been much opposition to containerisation, such were the potential economic benefits.

The Big Australia

One of the enduring debates in Australia since before Federation has been that between those who believe that the optimal and sustainable population in Australia is small (and possibly smaller than the current population) and proponents of a Big Australia. Advocacy of environmental determinism and consequently a small population is potentially a career limiting position – it is a dangerous idea. Griffith Taylor, the first head of geography at the University of Sydney in the 1920s, was one who faced considerable criticism from the media (the *Daily Telegraph* never changes!) and politicians, for questioning Australia's future population size. In the face of this opposition he moved to the United States and subsequently Canada to find a more congenial working environment (Strange and Bashford 2008). Former premiers (for example Carr 2016) can strongly advocate against expansion and population growth, and attract favourable comments from letter writers to the *Sydney Morning Herald,* but there is nothing as ex as an ex, and such sentiments are dismissed with a shrug of the shoulders by current politicians.

One of the favoured projects of those who support a Big Australia is "to stop water running to waste into the sea". The importance of freshwater flows for the maintenance of estuarine and coastal water ecosystems is not acknowledged (Adam 2012). Schemes which have been proposed including turning around the northern rivers of New South Wales and diverting flows into the Murray Darling basin, directing water from coastal rivers in north-east Queensland back over the Divide and constructing dams downriver in the Lake Eyre Basin, capturing the discharge of rivers flowing to the Gulf of Carpentaria, and sending water from north-west Western Australia to the south-west of that state. These would be capital expensive, with considerable environmental costs and doubtful benefits. For all that proponents included nationally revered figures like Bradfield, the engineer who built the Sydney Harbour Bridge, Davidson (1969) argued that there was little economic justification for proceeding with any of these schemes. However, visionary ideas are resistant to criticism and continue to appear every few years (see, for example, Katter 2012).

The north of Australia has been subject to numerous proposals for development for decades, and is currently touted as the future food bowl of Asia. The hyperbole ignores reality. The growing population of Asia will create demand for food, and Australia will undoubtedly contribute to food supplies. The demand will be created by a population numbering billions. Australia may be able to develop niche markets for high-quality gourmet foods, but the low fertility of most Australian soils and the climatic conditions will limit productivity to be sufficient for a only few tens of millions. Davidson (1965) wrote of the Northern Myth – 50 years later it is still a myth, unlikely to become a reality. Ideas for Northern development are dangerous – dangerous because they raise unrealistic expectations, consume funding and resources which might be better utilised elsewhere, and could result in substantial risks to the environment.

Concluding remarks

In the various examples discussed, dangers arise because of narrow approaches to complex problems. Picketty (2014) wrote: "To put it bluntly, the discipline of economics has yet to get over its childish passion for mathematics and for purely theoretical and often highly ideological speculation at the expense of historical research and collaboration with the other social sciences. Economists are all too often

preoccupied with petty mathematical problems of interest only to themselves. This obsession with mathematics is an easy way of acquiring the appearance of scientificity without having to answer the far more complex questions proposed by the world and living."

It is disappointing that he restricted the need for collaboration to the humanities – collaboration between economists and ecologists is urgently needed. The criticism of mathematics is harsh – maths is a tool and many complex problems cannot be solved without mathematical input.

However, the need for more cooperation between disciplines has long been recognised. Over the last few decades there have been numerous calls for more multidisciplinary research. Any collaboration needs to be between equal partners – a process which creates hierarchies with one discipline at the top and subordinate disciplines providing a service is unlikely to be successful. Despite calls for collaboration the fine words have not been matched by action. Grant applications for multidisciplinary search may be reviewed by experts in one or more of the disciplines involved and not assessed in a comprehensive way. Involvement in multidisciplinary projects is often not rewarded in promotion reviews. It is important to maintain specialities, and to produce experts in particular fields but part of the training of specialists should include recognition of what can be offered by perhaps very disparate disciplines. The failure to promote the correct balance between specialisation, generalisation and collaboration within educational institutions and research bodies is indeed a clear and present danger.

Acknowledgements

My interests in environmental history were kindled and nurtured over many years by the late Oliver Rackham, one of the most remarkable people it has been my privilege to have known. Oliver had a background in whole plant ecology and physiology, but became a pioneering environmental historian, not just in the boulder clay oak woodlands of lowland England, but also in the United States and around the Mediterranean. He also made pertinent observations on Australian forests and woodlands. He was a practical woodsman, whose skill as an axeman was legendary amongst those who participated with him in restoring coppicing as a management practice in woodland reserves.

I thank Scott Mooney for his advice, Dan Lunney for his advice and comments on earlier versions of the manuscript (and for his patience and indulgence during the manuscripts long gestation) and Beth Schultz for correspondence about a range of topics raised by the study. Jacinta Green provided invaluable assistance in controlling an increasingly untidy manuscript.

References

Adam, P. 1992. *Australian rainforests*. Oxford University Press, Oxford.

Adam, P. 2012. Introduction. Pp 2 -35 in *Estuary plants and what's happening to them in South-East Australia* edited by G. Sainty, J, Hosking, G. Carr and P. Adam. Sainty and Associates, Sydney.

Adam, P. and Williams, G. A. 2001. Dioecy, self-incompatibility and vegetative reproduction in Australian subtropical rainforest trees and shrubs. *Cunninghamia* **7:** 89-100.

Adam, P., Stricker, P and Anderson, D. 1989. Species richness and soil phosphorus in plant communities in coastal New South Wales. *Australian Journal of Ecology* **14:** 189-198. https://doi.org/10.1111/j.1442-9993.1989.tb01426.x

Adams, A. 1985. *Ansel Adams, an autobiography.* Little, Brown and Company. Boston.

Adams, M. A. and Attiwill, P. 2011. *Burning issues. Sustainability and management of Australia's southern forests.* CSIRO Publishing, Melbourne.

Albrecht, G. 2005. Solastalgia: a new concept in human health and identity. *PAN: Philosophy Activism Nature*. **3**: 41-44.

Albrecht, G., Sartore, G-M., Connor, L., Higginbotham, N., Freeman, S., Kelly, B., Stain, H., Tonna, A. and Pollard, D. 2007. Solastalgia: the distress caused by environmental change. *Australasian Psychiatry* **15**: S95-S98. https://doi.org/10.1080/1039856070128

Anemaat, L. 2014. *Natural curiosity. Unseen art of the First Fleet.* NewSouth Press, Sydney.

Arthur, W. and Morphy, F. 2005. Representations of space and place. Pp. 18-25 in *Macquarie Atlas of indigenous Australia. Culture and society through space and time*. Edited by W. Arthur and F. Morphy. The Macquarie Library, Sydney.

Ashby, E. 1947. *Scientist in Russia*. Penguin, Harmondsworth.

Ashton, D. H. 1976. The development of even age stands in *Eucalyptus regnans* F. Muell. in central Victoria. *Australian Journal of Botany* **24:** 397-414. https://doi.org/10.1071/BT9760397

Ashton, D. H. 1981. Fire in tall open forests (wet sclerophyll forest). Pp. 339-366 in *Fire and the Australian biota*. Edited by A. M. Gill, R. H. Groves and I. R. Noble. Australian Academy of Science, Canberra.

Aslet, C. 2013. No Sir David Attenborough, the end of the world is not nigh. *The Telegraph* 18 September 2013. Accessed 16 March 2016.

Attenbrow, V. 2010.*Sydney's Aboriginal past. Investigating the archaeological and historical records*. UNSW Press, Sydney.

Barnes, G. and Williamson, T. 2015. *Rethinking ancient woodland. The archaeology and history of woods in Norfolk*. University of Hertfordshire Press, Hatfield.

Barnes, S. 2012. We've saved the special, now for the ordinary. *The Times*. April 7, 2012 page 30.

Benjamin, B. 1964. John Graunt's "observations". *Journal of the Institute of Actuaries* **90**: 1-61.

Benson, J. S. and Redpath, P. A, 1997. The nature of pre-European native vegetation in south-eastern Australia: a critique of Ryan, D. G., Ryan, J. R. and Starr, B. J. (1995). The Australian landscape – observations of explorers and early settlers. (Murrumbidgee Catchment Management Committee: Wagga Wagga). *Cunninghamia* **5:** 285 – 328.

Birks, H. J. B. 2005. Mind the gap: how open were European primeval forests? *Trends in Ecology and Evolution*. https://doi.org/10.1016/j.tree.2005.02.001

Blackett, P. M. S., Bullard, E. and Runcorn, S. K. (Editors) 1965. A symposium on continental drift. *Philosophical Transactions of the Royal Society of London. A*. **258**: 1-308. I

Bonacina, L. C. W. 1937. Constable as a painter of weather. *Quarterly Journal of the Royal Meteorological Society*, **63:** 483 – 490. https://doi.org/10.1002/qj.49706327204

Bonacina, L. C. W. 1938. Turner's portrayal of weather. *Quarterly Journal of the Royal Meteorological Society* **64:**601-611. https://doi.org/10.1002/qj.49706427705

Bonyhady, T. 2000. *The colonial earth*. The Miegunyah Press, Melbourne.

Bowman, D. M. J. S. 1998. Tansley review no. 101. The impact of Aboriginal landscape burning on the Australian biota. *New Phytologist* **140:** 385-410. https://doi.org/10.1046/j.1469-8137.1998.00289.x

Bowman, D. M. J. S., Garde, M. and Saulwick, J. 2001. *Kunj-ken makka Man-wurkk*. Fire is the kangaroo's: interpreting Aboriginal accounts of landscape burning in Central Arnhem Land. Pp. 61-78 in *Histories of all ages. Essays in honour of Rhys Jones*. Edited by A. Jones, I, Lilley and S. O 'Connor. Pandanus Books, Canberra.

Bradshaw, S. D., Dixon, K. W., Hopper, S. D., Lambers, H. and Turner, S. R. 2011. Little evidence for fire-adapted plant traits in Mediterranean climate regions. *Trends in Plant Science* **6:** 69-76. https://doi.org/10.1016/j.tplants.2010.10.007

Brockman, J. (Ed). 2006. *What is your dangerous idea?* Pocket Books, London.

Bundock, M. 1898. *Notes on the Richmond blacks*. Unpublished MS (Bundock papers A6939) Mitchell Library, Sydney.

Burarrwanga, T. D, 2012. Pp xx in *Recognising Aboriginal and Torres Strait Islander Peoples in the Constitution. Report of the Expert Panel*. The Expert Panel, Canberra.

Buss, D. M., Haselton, M. G., Shakelford, T. K., Bleske, A. L. and Wakefield, J. C. 1998. Adaptations, exaptations, and spandrels. *American Pyschologist*. **53:** 533 – 548. https://doi.org/10.1037/0003-066X.53.5.533

BWBTexts 2014. *The Picketty phenomenon. New Zealand perspectives*. Bridget Williams Books, Wellington.

Cambage, R.H. 1920 Exploration beyond the Upper Nepean in 1798. Read before the Royal Australian Historical Society, Sydney, October 28 1919.

Carpenter, R. J., Holman, A. I., Abell, A. D. and Grice, K. 2016. Cretaceous fire in Australia: a review with new geochemical evidence, and reference to the rise of angiosperms. *Australian Journal of Botany*, **64:** 564 – 578. https://doi.org/10.1071/BT16109

Carr, B. 2016. Big Australia wants bold ideas, such as rezoning Point Piper. *Sydney Morning Herald* 15 March 2016 page 17.

Childers, R. E. 1903. *The Riddle of the Sands. A record of secret service*. Smith, Elder & Co., London.

Chisholm, A. H. 1955. How and when the lyrebird was discovered. *Emu* **55:** 1-15. https://doi.org/10.1071/MU955001

Clark, G. 2301414. *The son also rises. Surnames and the history of social mobility*. Princeton University Press, Princeton.

Colloff, M. J. 2014. *Flooded forest and desert creek. Ecology and history of the river red gum*. CSIRO Publishing, Melbourne.

Cope, T. and Gray, A. 2009. *Grasses of the British Isles*. BSBI, London.

Cowen, T. 2014. Capital punishment: Why a global tax on wealth won't end inequality. *Foreign Affairs* **93(3)**: 158-164.

Cumming, H. (ed). 2013. *The greatest wonder of the world*. State Library of New South Wales, Sydney.

Daly, M. T. 1982. *Sydney boom. Sydney bust*. Allen & Unwin, Sydney.

Darwall, R. 2012. *The age of global warming. A history*. Quartet Books, London.

Davidson, B. R. 1965. *The Northern Myth. Limits to agricultural*

and pastoral development in tropical Australia. Melbourne University Press, Melbourne.

Davidson, B. R. 1969. *Australia wet or dry? Physical and economic limits to the expansion of irrigation*. Melbourne University Press, Melbourne.

Dixon, R. 2006. *Carlyle, Malthus and Sismondi: the origins of Carlyle's dismal view of political economy*. The University of Melbourne Department of Economics. Research Paper Number 965.

Ebeling, R. M. 2006. John Maynard Keynes: the damage still done by defunct economist. *The Freeman. Ideas on Liberty*. 2-3.

Ehrlich, P. R. 1968. *The population bomb.* Ballantine Books, New York.

Ehrlich P. R. and Ehrlich, A, 2013a. Can a collapse of global civilisation be avoided? *Proceedings of the Royal Society B*, **280**, 20122845 (http://dx. doi.org 10. 1098/rspb. 2012. 2845. http://dx. doi.org

Erhlich, P. R. and Ehrlich, A. 2013b, future collapse: how optimistic should we be? *Proceedings of the Royal Society B*, **280**, 2013373. http://dx.doi.org/10.1098/rspb.2013.1377.

Enright, N. J., Lamont, B. B. and Miller, B. P. 2005. Anomalies in grasstree fire history reconstructions for south-western Australian vegetation. *Austral Ecology* **30**: 668–673. https://doi.org/10.1111/j.1442-9993.2005.01509.x

Etheridge, R. 1918. The dendroglyphs, or 'carved trees" of New South Wales. *Memoirs of the Geological Survey of New South Wales. Ethnological Series, No. 3.* Government Printer, Sydney.

Floud, R.C. 1979. *An introduction to quantitative methods for historians.* 2nd ed. Cambridge University Press, Cambridge.

Gammage, B. 2005. "… far more happier than we Europeans": Aborigines and farmers. *London Papers in Australian Studies No.12.* Menzies Centre for Australian Studies, London.

Gammage, B. 2008. Plain facts: Tasmania under aboriginal management. *Landscape Research,* **33**: 241-245. https://doi.org/10.1080/01426390701767278

Gammage, B. 2011a. Victorian landscapes in 1788. *Studies in the History of Gardens and Designed Landscapes* **31**: 83-87. https://doi.org/10.1080/14601176.2011.556367

Gammage, B. 2011b. Fire in 1788. The closest ally. *Australian Historical Studies*, **42**: 277 – 288. https://doi.org/10.1080/1031461X.2011.566273

Gammage, B. 2011c. *The Biggest Estate on Earth. How Aborigines made Australia.* Allen & Unwin, Sydney.

Gill, A. M. 1981a. Coping with fire. Pp. 65-87 in *The biology of Australian plants*, edited by J. S. Pate and A. J. McComb. University of Western Australia Press, Perth.

Gill, A. M. 1981b Adaptive responses of Australian vascular plant species to fires. Pp. 243-271 in *Fire and the Australian biota*, edited by A. M. Gill, R. H. Groves and I. R. Noble. Australian Academy of Science, Canberra.

Giri, A, Armstrong, B and Rajashekar, C. B. 2016. Elevated carbon dioxide levels suppresses nutritional quality of lettuce and spinach. *American Journal of Plant Sciences* **7:** 246-258.

Goldsmith, M.1988. *Sage. A life of J. D. Bernal.* Hutchinson, London.

Goodall, D. W. 2014. A century of vegetation science. *Journal of Vegetation Science*, **25**: 913-916. https://doi.org/10.1111/jvs.12182

Gould, S. J. and Vrba, E. S. 1982. Exaptation – a missing term in the form of science. *Paleobiology* **8:** 4 -15. https://doi.org/10.1017/S0094837300004310

Grant, M. J., Hughes, P. D. M. and Barber, K. E. 2015. Climatic influence on early to mid-Holocene fire regimes within temperate woodlands: a multi-proxy reconstruction from the New Forest, southern England. *Journal of Quaternary Science* **29**: 175-188. https://doi.org/10.1002/jqs.2692

Griffiths, S. J. Bale, C., Adam, P. and Wilson, R. 2003. Wallum and related vegetation on the NSW North Coast: description and phytosociological analysis. *Cunninghamia* **8**: 220-252.

Griffiths, T. 2001. *Forests of ash. An environmental history.* Cambridge University Pess, Cambridge.

Hansen, D. 2003a. The life and work of John Glover. Pp. 22-109 in *John Glover and the colonial picturesque.* Edited by D. Hansen. Tasmanian Museum and Art Gallery and Art Exhibitions Australia, Hobart.

Hansen, D. 2003b. Catalogue of paintings and drawings. Pp. 134-241 in *John Glover and the colonial picturesque.* Edited by D. Henson. Tasmanian Museum and Gallery and Art Exhibitions Australia, Hobart.

Hansen, A. and Davies, M. 2014. *The library at the end of the world. Natural Science and its illustrators*. Royal Society of Tasmania, Hobart.

Hartley, L. P. 1953. *The go-between*. Hamish Hamilton, London.

Hateley, R. 2012 *The Victorian Bush, its 'original and natural' condition*. Polybractea Press, Melbourne.

Hawking, S. 1988. *A brief history of time.* Bantam Dell Publishing Group. New York.

Heathcote, B. L. 1976. Early European perceptions of the Australian landscape: the first hundred years. Pp. 29-46 in *Man*

and landscape in Australia. Towards an ecological vision. Edited by G. Seddon and M. Davis. AGPS, Canberra.

Heathcote, C. 2016. Did Arthur Boyd paint Aboriginal genocide? *Quadrant* **60(3)**: 77-86.

Hefner, R. A. 2014. The United States of gas: why the shale revolution could only have happened in America. *Foreign Affairs* **93(3)**: 9-14.

Hill, R. S. and Jordan, G. J. 2016. Deep history of wildfire in Australia. *Australian Journal of Botany*, **64**:557 – 563. https://doi.org/10.1071/BT16169

Hiscock, P. 2014. Creators or destroyers. The burning question of human impact in ancient Aboriginal Australia. *Humanities Australia* **5**: 40-52.

Hockney, D. 2011 *Secret knowledge: rediscovering the lost technique of the old masters*. Thames & Hudson, London.

Honeywood, S. 2012. *Photography for fieldwork*. NSW Department of Primary Industries, Sydney.

Hoskins, I. 2009. *Coast. A history of the New South Wales edge*. NewSouth, Sydney.

Hoskins W.G. 1955. *The making of the English landscape*. Hodder and Stoughton. London.

Hunt, S. 2007. The catalogue. Pp 25-129 in *Sydney views 1788-1888 from the Beat Knoblauch collection edited by S. Hunt*. Historic Houses Trust, Sydney.

Hurlbert, S. H. 1984. Pseudoreplication in the design of field experiments. *Ecological Monographs* **54:** 187-211. https://doi.org/10.2307/1942661

Hurlbert, S. H. 2013. Pseudofactorialisation, response structures and collective responsibility. *Austral Ecology* **38**: 646-663. https://doi.org/10.1111/aec.12010

Hutchens, G. 2017. Australia's Chief Scientist compare Trump to Stalin over climate censorship. www./the guardian.com/science/2017/feb/06/

Huxley, J. 1942. *Evolution: the modern synthesis*. Allen & Unwin, London.

Huxley, J. 1949. *Soviet genetics and world science: Lysenko and the meaning of heredity*. Chatto & Windus, London

International Court of Justice 2014. Whaling in the Antarctic (Australia v. Japan: New Zealand intervening), judgement. *I. C. J. Reports* **2014:** 226-300

Jessell C. 2011. *A legal history of the English landscape*. Wildly, Simmons & Hill. London.

Jevons, W. S. 1865. *The coal question: an enquiry concerning the progress of the nation, and probable exhaustion of our coal mines*. Macmillan, London.

Jones, M. 2015. Heroes and villains. Strutt's Australia. *The National Library of Australia Magazine* **7**: 2-6.

Kates, S. 2014. What if the planet is not warming but cooling. *Quadrant* **58(9)**: 60-65.

Kattter, B. 2012. *An incredible race of people. A passionate history of Australia.* Murdoch Books Australia, Sydney, Australia.

Keeley, J. E. and Bond, W. J. 2001. On incorporating fire into our thinking about natural ecosystems: a response to Saba and Howes. *American Naturalist* **158**: 664-670. https://doi.org/10.1086/323594

Keeley, J. E., Pausas, J. G., Rundel, P. W., Bond, W. J. and Bradstock, R. A. 2011. Fires as an evolutionary pressure shaping plant traits. *Trends in Plant Science*, **16:** 486 – 411. https://doi.org/10.1016/j.tplants.2011.04.002

Kelly, M. J. 2013. Why a collapse of global civilisation will be avoided: a comment on Ehrlich & Ehrlich. *Proceedings of the Royal Society B* **280** 20131193. http:// dx.doi.org./10.1098/rspb 2013 – 1193

Keogh, L. 2011. Duboisia pituri: a natural history. *Historic Records of Australian Science* **22**: 199-214. https://doi.org/10.1071/HR11008

Keynes, J. M. 1936. *The General Theory of employment, interest and money*. Macmillan, London.

Kimber, R. G. and Friedel, M. H. 2015. Challenging the concept of Aboriginal mosaic fire practices in the Lake Eyre Basin. *The Rangelands Journal* **37**: 623 – 630. https://doi.org/10.1071/rj15057

Kington, J. 2010. *Climate and weather*. Harper Collins, London.

Kirkpatrick, A. H. 2013. Managing moorland in the UK. Pp 323-338 in *Economy and ecology of heathland*. Edited by W. H, Diemont, W.J. M Heijman, I. Siebel, and Webb, N. R.. KNNV, Ziest. https://doi.org/10.1163/9789004277946_022

Klein, N. 2014. *This changes everything. Capitalism vs the climate*. Allen Lane, London.

Kuhn, T. S. 1962. *The structure of scientific revolutions*. University of Chicago Press, Chicago.

Lawrence, D. H. 1923. *Kangaroo.* Martin Seckert, London.

Lawson, N. 2008. *An appeal to reason. A cool look at climate warming*. Duckworth Overland, London.

Lindenmayer, D, Blair, D, McBurney, L. and Banks, S. 2015.

Mountain ash. Fire, logging and the future of Victoria's giant forest. CSIRO Publishing, Melbourne.

Lindenmayer, D. B., Hobbs, R. J., Likens, G. E., Krebs, C. J., and Banks, S. C. 2011. Newly discovered landscape traps produce regime shifts in wet forests. *Proceedings of the National Academy of Sciences* **108:** 15887-15891. https://doi.org/10.1073/pnas.1110245108

Lovegrove, R. 2007. *Silent Fields*. Oxford University Press, Oxford.

Low, T. 2014. *Where song began. Australia's birds and how they change the world*. Viking, Melbourne.

Luck, G. 2014. The fishiest fish. *Quadrant* **58(7)**: 90-94.

Lunney, D. 2012. What's the difference between climate science and climate journalism?. Pp. 23-44 in *Science under siege: zoology under threat?* Edited by P. Banks, D. Lunney and C. Dickman. Royal Zoological Society of New South Wales, Mosman, NSW. https://doi.org/10.7882/FS.2012.034

Lunney, D., Lunney, H. W. M. and Recher, H. F. 2008. Bushfire and the Malthusian guillotine: survival of small mammals in a refuge in Nadgee Nature Reserve, south-eastern New South Wales. *Pacific Conservation Biology* **14**: 263-278. https://doi.org/10.1071/PC080263

Lunney, D. and Hutchings, P. (eds). 2012. *Wildlife and Climate Change: Towards robust conservation strategies for Australian fauna.* Royal Zoological Society of Sydney, Mosman, NSW,

McLean, I. W. 2016. *Rattling spears. A history of indigenous Australian art.* Reaction Books, London.

Macqueen, A. 2013. "The Biggest Estate on Earth: How Aborigines Made Australia" By Bill Gammage 2011. A Blue Mountains Critique. *Heritage. Newsletter of the Blue Mountains Association of Cultural Heritage Organisations Inc.* **28**: 17-21.

Marshall, A. 1890. *Principles of Economics*. Macmillan, London.

Martyr, P. 2014. Should the Commonwealth fund medical research? *Quadrant* **58(7/8)**: 78-84.

Mayhew, R. J. 2014. *Malthus. The life and legacies of an untimely prophet*. Belknap Press, Cambridge (Mass.). https://doi.org/10.4159/harvard.9780674419407

Maynard, J. 2014. *True light and shade. An Aboriginal perspective of Joseph Lycett's art.* National Library of Australia Publishing, Canberra.

Maynard, J. 2015. *The unseen Anzac. How an enigmatic polar explorer created Australia's World War I photographs.* Scribe, Melbourne.

McNeill, J. 2000. *Something new under the sun. An environmental history of the 20th century world.* Allen Lane, London.

McPhee, J, 2006a. Joseph Lycett: a biography. Pp. 12-29 In *Joseph Lycett. Convict Artist*. Edited by J. Mcphee. Historic Houses Trust, New South Wales, Sydney.

McPhee, J. 2006b, Botanical Works. Pp. 52-61 In Joseph Lycett Convict Artist. Edited by J. McPhee. Historic Houses Trust, New South Wales, Sydney.

Melville, R. 1948. The British elms. *The New Naturalist. A Journal of British Natural History.* Spring: 36-41.

Miller, B. P., Walshe, T., Enright, N. J. and Lamont, B. B. 2007. Error in the inference of fire history from grasstrees. *Austral Ecology* **32**: 908–916. https://doi.org/10.1111/j.1442-9993.2007.01779.x

Miller, G., Friedel, M., Adam, P and Chewings, V. 2010. Ecological Impacts of buffel grass (Cenchrus ciliaris L,) invasion of Central Australia – does field evidence support a fire-invasion feedback? *The Rangelands Journal* **32**: 353-365. https://doi.org/10.1071/RJ09076

Mitchell, K. J. G. 2005. How open were European primeval forests? Hypothesis testing using palaeoecological data. *Journal of Ecology* **93:**168-177.

Monbiot, G. 2013. *Feral. Searching for enchantment on the frontiers of rewilding.* Allen Lane, London.

Mooney S.D., Harrison S.P., Bartlein P.J., Daniau A.-L., Stevenson J., Brownlie K., Buckman S., Cupper M., Luly J., Black M., Colhoun E., D'Costa D., Dodson J., Haberle S., Hope G.S., Kershaw P., Kenyon C., McKenzie M. and Williams N. 2011. Late Quaternary fire regimes in Australia. *Quaternary Science Reviews* **30**: 28-46. https://doi.org/10.1016/j.quascirev.2010.10.010

Mooney, S. D., Radford, K. L. and Hancock, G. 2001. Clues to the 'burning question': pre-European fire In the Sydney coastal region from sedimentary charcoal and palynology. *Ecological Management and Restoration* **2**: 203-212. https://doi.org/10.1046/j.1442-8903.2001.00085.x

Morse, E. L. 2014. Welcome to the revolution: why shale Is the next shale. *Foreign Affairs* **93(3):** 3-7.

Murray, J. R. 2011. *A tour of the English Lakes with Thomas Gray and Joseph Farrington RA.* Frances Lincoln Ltd, London.

Odum, E. P. 1971. *Fundamentals of Ecology.* W. B. Saunders Company, Philadelphia.

Parker, G. 2013. *Global Crisis. War, climate change and catastrophe in the seventeenth century.* Yale University Press, New Haven.

Partner, J. 2002. Artificial Eye. *The Cambridge Quarterly*. **31**: 345-349. https://doi.org/10.1093/camqtly/31.4.345

Pascoe, B. 2014. *Dark Emu: Black Seeds: Agriculture or Accident?* Magabala Books, Broome.

Pausas, J. G., Keeley, J. E. and Schwilk, D. W. 2017. Flammability as an ecological and evolutionary driver. *Journal of Ecology*, **105**: 289 – 297. https://doi.org/10.1111/1365-2745.12691

Perry, G. L. W., Wilmshurst, J. M. and McGlone, M. S. 2014. Ecology and long-term history of fire in New Zealand. *New Zealand Journal of Ecology* **38**: 157-176.

Peters,R.A.1991. *Critique for Ecology*. Cambridge University Press, Cambridge.

Picketty, T. 2014. *Capital In the twenty-first century*. Translated by A. Goldhammer, Belknap Press, Cambridge (Mass). https://doi.org/10.4159/9780674369542

Pringle, P. 2008. *The murder of Nikolai Vavilov: the story of Stalin's persecution of one of the greatest scientists of the twentieth century*. Simon and Schuster, New York.

Rackham, O. 2006. *Woodlands*. Harper Collins, London.

Rackham, O. 1989. *The Last Forest. The Story of Hatfield Forest.* Dent, London.

Ross, P. and Adam, P. 2013. Climate change and intertidal wetlands. *Biology* **2**: 445-480. https://doi.org/10.3390/biology2010445

Rossiter, N. A., Satterfield, S. A., Douglas, M. M. and Hutley, L. B. 2003. Testing the grass-fire cycle: alien grass invasion in the tropical savanna of Northern Australia. *Diversity and Distributions* **9**: 169-176. https://doi.org/10.1046/j.1472-4642.2003.00020.x

Rothwell, N. 2011. A Land Crafted By Social Endeavour. *Weekend Australian, Review.* 20-21. October 8-9.

Rowse, T. 2013. The biggest state on earth: How Aborigines made Australia. *Anthropological Forum: a Journal of Social Anthropology and Comparative Sociology*. **22**: 311-313.

Sabbagh, K. 1999. *A Rum affair. How botany's 'Piltdown Man' was unmasked*. Allen Lane, London.

Sakaguchi, S., Bowman, D. M. J. S. ,Prior, L. D., Crisp, M. D., Linde C. C., Tsamura, Y. and Isagi, Y. 2013. Climate, not Aboriginal landscape burning, controlled the historical demography and distribution of fire-sensitive conifer populations across Australia. *Proceedings of the Royal Society B* **280**: 2013-2182. https://doi.org/10.1046/j.1472-4642.2003.00020.x

Salaman, R. 1949. *The history and Influence of the potato*. Cambridge University Press, Cambridge.

Santayana, G. 1905. Reason in common sense. Volume 1 in *The Life of Reason.* Charles Scribner's Sons. New York City.

Scruton, R. 2012. *Green Philosophy. How to think seriously about the planet.* Atlantic Books, London.

Seddon, G. 1972. *Sense of Place: response to an environment.; the Swan Coastal Plain, Western Australia*. University of Western Australia Press, Perth.

Seddon, G. 1976. The evolution of perceptual attitudes. Pp 9-17 in *Man and landscape In Australia. Towards an Ecological Vision.* Edited by G. Seddon and M. Davis. AGPS, Canberra.

Sheail, J. 1971. *Rabbits and their history.* David & Charles, Newton Abbot.

Sinclair, J. 2016. Valuing vicarious visitation. An essay on the role of National Parks. *Moonbi* **133:** 2-3.

Small, R. 2015. Livestock biodiversity; coming of age? *British Wildlife* **27**: 17-24.

Smith, B. 1976. On perceiving the Australian suburb. pp 289-304 in *Man and landscape in Australia. Towards an ecological vision.* Edited by G. Seddon and M. Davis. AGPS, Canberra.

Smith, D. F. 2014. In praise of exotic species. *Quadrant* **58(1)**: 48-55.

Smith, P. 2014. The questionable equations of Thomas Picketty. Quadrant **58(June)**: 14-18.

Smout, T. C. 2009. *Exploring environmental history. Selected essays*. University of Edinburgh Press, Edinburgh.

Southwood, T. R. E. 1977. Habitat. The templet for ecological strategies? Presidential Address to the British Ecological Society, 5 January 1977. *Journal of Animal Ecology* **46**: 337-365.

Spencer, J. 1981. *William Dampier 1652 -1715. A voyage to New Holland: the English voyage of discovery to the South Seas in 1699*. Alan Sutton, Gloucester.

Staples, M. 2003. Sunshine and Shadow: the John Glover sketchbooks. Pp. 248-267 in *John Glover and the Colonial Picturesque*. Edited by D. Hansen. Tasmanian Museum and Art Gallery and Art Exhibitions Australia, Hobart.

Steinberg, T. 2014. *Gotham unbound. The ecological history of greater New York*. Simon and Schuster, New York.

Strange, C. and Bashford, A. 2008. *Griffith Taylor .Visionary Environmentalist Explorer.* National Library of Australia, Canberra.

Thompson, K. 2014. *Where do camels belong? The story and science of invasive species.* Profile Books, London.

Thompson, P. 2010. *Seeds, sex and civilization. How the hidden life of plants has shaped our world.* Thames & Hudson, London.

Thornes, J. E. 2000. A brief history of weather in European landscape art. *Weather*, **55**; 363-375. https://doi.org/10.1002/j.1477-8696.2000.tb04022.x

Tobler, R., Rorlach, A., Soubrier, J., Bover, P., Liamas, B., Tuke, J., Bean, N., Abdullah Highfold, A., Agius, S., O'Donoghue, A., O'Loughlin, I., Sutton, P., Zilio, F., Walshe, K., Williams, A.N., Turney, C. S. M., Williams, M., Richards, S. M., Mitchell, R. J., Kowal, E., Stephen, J. R., Williams, l., Haak, W., and Cooper, A. 2017. Aboriginal mitogenomes reveal 50, 000 years of regionalism in Australia. *Nature.* https://doi.org/10.1038/nature21416

Tng, D. Y. P., Goosem, S., Jordan, G. J. and Bowman, D. M. J. S. 2014. Letting be - rethinking active fire management of old-growth forest in the Australian tropics. *Journal of Applied Ecology*. **51**: 555-559. https://doi.org/10.1111/1365-2664.12233

Tng, D.Y. P. John, G. J., Bowman, D. M. J. S. 2013. Plant traits demonstrate that temperate and tropical giant eucalypt forests are convergent with rainforest and not savanna. *PloS ONE* **(12):** e84378. https://doi.org/10.1371/journal.pone.0084378

Vera, F. W. M. 2000. *Grazing ecology and forest history*. CABI Publishing, Wallingford. https://doi.org/10.1079/9780851994420.0000

Vigilante, T. 2001. Analysis of explorers records of Aboriginal landscape burning in the Kimberley Region of Western Australia. *Australian Geographical Studies* **39**: 135-155. https://doi.org/10.1111/1467-8470.00136

Von Platen, J., Kirkpatrick, J.B. and Allen, K.J. 2011. Variation in decadal fire frequency in southeastern Tasmanian dry eucalypt forest 1740–2004. *Australian Forestry* **74**: 180–189. https://doi.org/10.1080/00049158.2011.10676361

Ward, D.J. 2009. Bushfire history from grasstrees at Eneabba, Western Australia. *Journal of the Royal Society of Western Australia* **92**: 261-268

Watson, D. 2014. *The Bush. Travels in the heart of Australia*. Hamish Hamilton, Melbourne.

Wegener 1915. *The origin of the continents and oceans*. (Translated J. Briam 1966) Dover, New York.

Weston, P. H. 2014. What has molecular systematics contributed to our knowledge of the plant family Proteaceae? Pp. 365 -397 In *Molecular plant taxonomy methods and protocols*. Edited by P Besse. Springer Science, New York. https://doi.org/10.1007/978-1-62703-767-9_18

White, P. 1957. *Voss.* Eyre & Spottiswoode, London.

Whitehouse, H.L.K. 1974. *Towards an understanding of the mechanism of heredity*. Edward Arnold, London.

Williams, A.N., Mooney, S.D., Sisson, S.A. and Marlon, J. 2015. Exploring the relationship between Aboriginal population indices and fire in Australia over the last 20,000 years. *Palaeogeography, Palaeoclimatology, Palaeoecology* **432**: 49-57. https://doi.org/10.1016/j.palaeo.2015.04.030

Williams, M. 1989. *Americans & their forests. A historical geography*. Cambridge University Press, Cambridge.

Williams, M. 2003. *Deforesting the Earth. From prehistory to global crisis*. Chicago University Press, Chicago.

Wilson, D. M. 2011. *The last photographs of Captain Scott*. Little, Brown & Company, New York.

Wilson, E.O. 1984. *Biophilia.* Harvard University Press, Cambridge (Mass).